INSTRUMENTS and AUTOMATION

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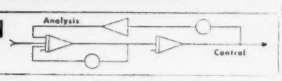
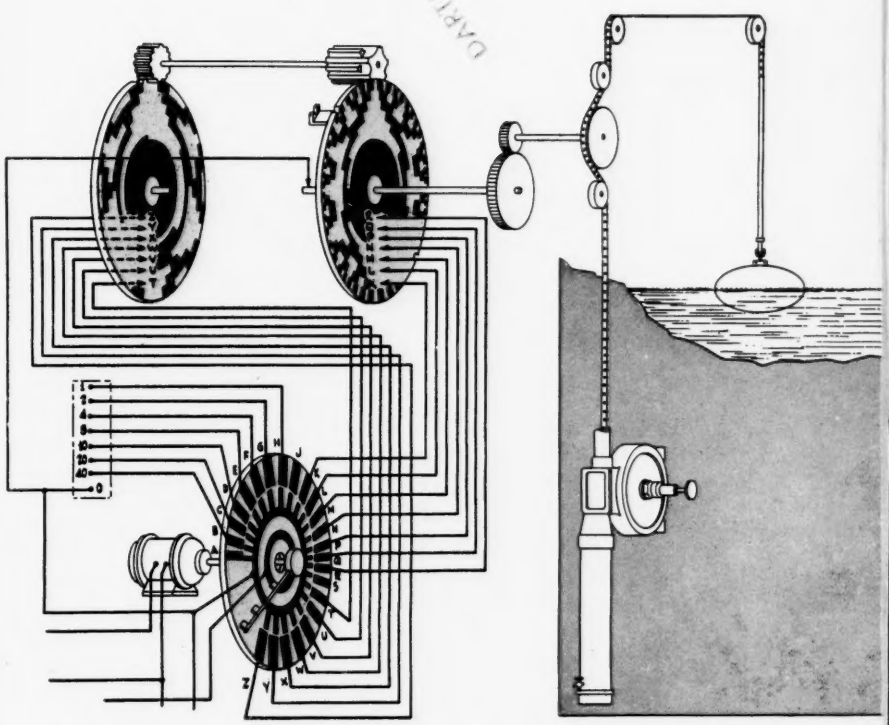


... in this issue:

...gital Automation 1297
...mputer Control of ...Rolling Mill 1303
...ntrol Valves 1306
...ctronic Circuitry 1312
...ction Pyrometry 1314
...ntinuous Galvanizing 1321
...celerometer ...Calibration 1322
...ocess Data— ...Digital or Graphic? 1328
...rker Generator 1329

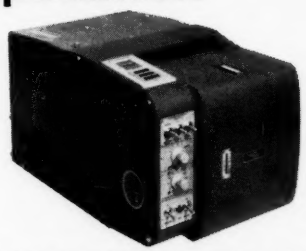


REMOTE TANK GAGING
. . . . page 1344

...ol. 29 No. 7 **JULY 1956**

A MIDWESTERN OSCILLOGRAPH
for every recording application

This tabulation shows the many types of MIDWESTERN recording oscillographs available today.



SPECS

Model	Maximum Trace Capacity (1)	Dimensions Inches (2)	Weight Pounds (3)	Record Speed Range Inches/Sec	Record Width Inches	Magazine Capacity Feet (5)	Power Requirements	Timing Lines Sec/Line	Optical Arm Inches	Temperature Range °F	Maximum Acceleration G's	Model
560	14	5¾ x 8⅝ x 7 7/16	9	.375 To 8	3.625	50	28 Volts d.c. 3 Amps Max.	—	6.821	0 to + 160	20 (8)	560
580		7⅛ x 7⅞ x 13½	22.5	.50 To 44.75 (4)		100	28 Volts d.c. 15 Amps Max.	.01 And/Or .10	7.375	−65 to + 190	20	580
581		7⅛ x 7⅞ x 15⅛	28.5									581
544	36	11½ x 12⅞ x 20	75	1 To 50	8	200	28 Volts d.c. 10 Amps Max. or 115 Volts, 60 cps 3 Amps Max.		14.469	+ 32 to + 160	1	544
570	50	11½ x 16⅛ x 20	97		12							570
590	36	11 x 11⅝ x 21⅞	90	.002 To 129.9	7	150	(6)	(7)	11.00	−65 to + 160	15	590
591	50	11 1/16 x 16 13/16 x 24¼	130		12	250						591

FEATURES

Model	Record Numbering	Trace Identification	Automatic Record Length	Timing Line Intensity Control	Galvo Lamp Intensity Control	Record Used Indicator	Recording Malfunction Indicator	Galvo Lamp Burnout Indicator	Timing Lamp Burnout Indicator	Rotary Scanning	Remote Control	Model
560	—	—	—	—	√	—	—	—	—	—	—	560
580	—	√	—	√	√	√	—	√	√	—	√	580
581	√	√	√	√	√	√	√	√	√	—	√	581
544	√	√	√	(9)	√	√	√	√	(9)	√	√	544
570	√	√	√		√	√	√	√		√	√	570
590	√	√	√		√	√	√	√		√	√	590
591	√	√	√		√	√	√	√		√	√	591

NOTES
(1) Using MIDWESTERN 102 Galvanometers.
(2) Dimensions include all external controls and fittings but do not include mating electrical connectors or shock-mount base.
(3) Weight does not include shock-mount base.
(4) A low speed version of these models is available with all recording speeds reduced by a factor of 60.
(5) Listed magazine capacities are with Kodak Linagraph #809 Paper. Other standard recording paper or film may also be used. Larger capacity magazines are available for the 580, 581, 590, and 591 Models.
(6) May be operated from 28 volts dc, 15 amps max.; or 115 volts, 60 or 400 cps single phase, 5 amps max. by means of interchangeable plug-in power supply units.
(7) Timing lines of .001 and/or .01; .01 and/or .10; or .10 and/or 1.0 seconds intervals, by means of interchangeable plug-in units.
(8) A special version of this model is available which will withstand shock accelerations in excess of 1000 gravities.
(9) Timing lines are produced by electronic flasher tubes. Due to their much longer operating life, warning indicators are not required; and because of their flash illumination characteristic, intensity adjustments are not necessary.

for complete details on the above oscillographs — and other MIDWESTERN test recording instruments and servo components — write

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Apr. 19, 1957
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AC Input:	105-125 Volts, (for 2-32 V.DC), 110-125 V. (for 32-36 V.DC), 1 phase, 60 cps (8 amps)
Ripple:	1% rms max. (@ 36 volts and full load. increases to 2% @ 2 volts and full load).

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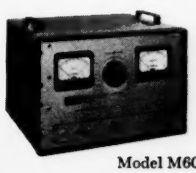


Model M60V

0-32 VOLTS @ 25 AMPS SPECIFICATIONS

Regulation:	±1% @ 28 Volts (Regulation increases to 2% over range of 24-32 volts; does not exceed 2 volts over 4-24 volt range. Not stabilized for AC line changes.)
AC Input:	115 Volts, 1 phase, 60 cps (12 amps).
Ripple:	1% rms (@ 32 volts and full load—2% rms max. @ any voltage above 4 volts).

Model MR1040-30A

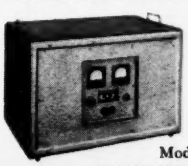
5-40 VOLTS @ 30 AMPS SPECIFICATIONS

Regulation:	±1% (over entire 5-40 volt range)
AC Input:	100-130 Volts, 1 phase, 60 cps
Ripple:	1% rms

Model 28-30 WXM

24-32 VOLTS @ 30 AMPS SPECIFICATIONS

Regulation:	±½%
AC Input:	100-125 Volts, 1 phase, 60 cps (20 amps). (Unit rated for DC output of 28 volts ±10% for 95-130 volt input.)
Ripple:	1% rms



Model MR2432-100XA

24-32 VOLTS @ 100 AMPS SPECIFICATIONS

Regulation:	±½%
AC Input:	208, 230 or 460 Volts, ±10%, 3 phase, 60 cps (14, 12 and 6 amps respectively). 230 volt input will be supplied unless otherwise specified.
Ripple:	1% rms

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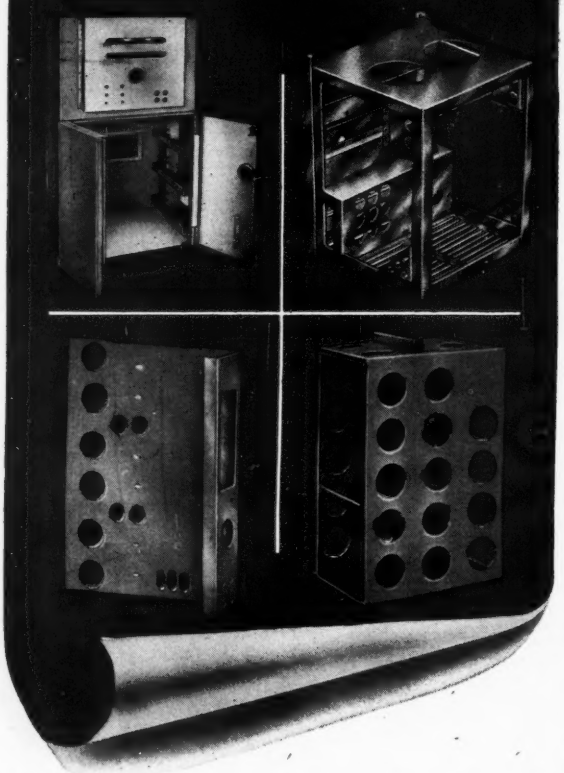

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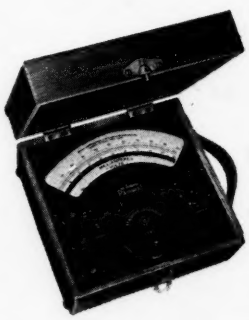

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July 1956

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Editorial

The Social Reactor—About to Explode? 1293

Are We Thinking Too Small? 1294

Feature Articles

High-Speed Digital Conversion 1297
Martin Klein, Frank K. Williams and Harry C. Morgan

Computer Control of a Rolling Mill Schedule 1303
A. H. Kuhnel

Solenoid and Motor Actuators 1306
C. S. Beard

Electronic Circuitry 1312
Charles F. Kezer and Milton H. Aronson

Suction Pyrometry 1314
T. Land

Continuous Galvanizing 1321

Accelerometer Calibration by Ballistic Pendulum 1322
Alvin B. Kaufman

Process Data—Digital or Graphic? 1328
Nathanial Brewer

Timing Marker Generator 1329
Loren E. Bollinger

The Simulation Council Newsletter

..... 1337

Journal of the Southern California Meter Association

Selection and Installation of Remote Tank Gages 1344
H. Dickinson

Other Regular Features

Letters to the Editor 1241
Inquiries 1248
Trends 1253
Panhandle Pete 1257
News 1262
Stock Report 1276
Biographies of Significance 1287
Books 1291
Events Calendar 1350
New Instruments 1352
Briefs 1406
New Literature 1418
Advertisers' Index 1430
Searchlite Section 1432
Inquiry Card 1433

THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL FOR 28 YEARS — SINCE JANUARY 1928

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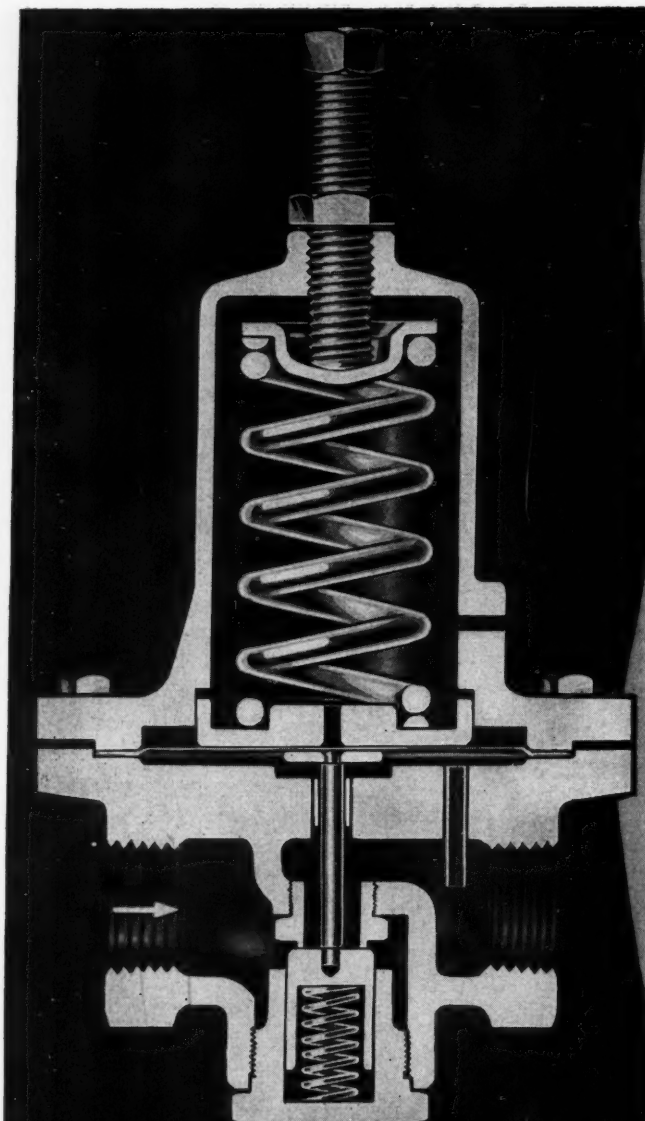

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Letters to the editor

Editor, I&A:

Subject: Terminology of Control Valves
by Washburn & Milham,
May issue, *I&A*.

It seems that the authors, in selecting the term "Diaphragm Motor" as a standard, are years behind in their thinking.

The term "motor" as applied to linear actuators started to wane years ago. Some companies still remember government inspectors insisting to be shown "motors" in Diaphragm Motors.

But let us leaf through May issue of *I&A* for ads and articles to gage current terminology:

p. 833—Manning, Maxwell & Moore, Inc.—*Electro-hydraulic Control Valve Operator*

p. 873—Moog Valve Co., Inc.—*Electro-hydraulic servo Actuator*

p. 895—"*Actuator Design*" by C. S. Beard, Foster Engineering—Quote "A control valve has two basic parts: (1) A body comprising plug and associated parts and (2) an actuator, comprising means for operating the plug."

p. 899—Standard classification and terminology for *Power Actuated Valves*—Fluid Control Institute.

p. 919—Fisher Governor Company—*Improved - Diaphragm Operator*

p. 949—Bristol Co.—*Diaphragm Control Valve*

In addition: NED-518B6—Askania Regulator Company—*Electro Hydraulic Valve Actuator*

I&A, p438—Keystone Valve Corp.—*Diaphragm Actuator—Electric Actuator—Hydraulic Actuator—Gear Actuator—*

Term "motor" as applied to linear actuators *is nowhere used.* So, why was it recommended?

The objective of rational terminology is not to choose words just because such were in vogue years ago and may have sentimental value to some, but to evaluate, to rationalize, to simplify and to select so as to eliminate ambiguity and misuse.

"The Integration of Concepts in the Terminology of Measurement and Control" by H. L. Mason admirably expresses the objectives, duties and methods in developing rational terminology.

In my opinion the authors failed to . . . apply fundamental concepts; instead they took the easy road to champion the redundant, superfluous, undoubtedly *due for revision* term "Motor Operator" from ASME definition 702A, which is on the way to oblivion: "A *Motor Operator* is that portion of the controlling means which applies power for operating final control element."

To satisfy broad fundamental concepts, as have been adopted by number of industries and as currently used by competent writers . . . ASME definition should read:

"An *Actuator* is that portion of the controlling means which applies power for operating final control element."

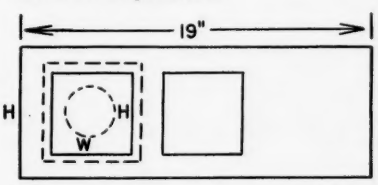
With overwhelming evidence of basic concepts well substantiated . . . it is hoped that in consideration of the above the authors will withdraw their recommendation.

Nikolai Belaef
Chief Engineer
Klipfel Valves, Inc.
Hamilton, Ohio

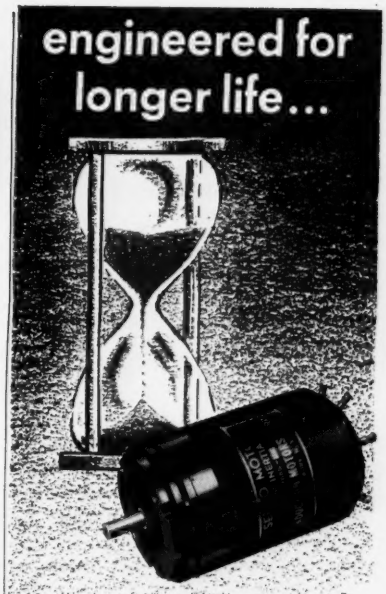
Editor, I&A:

Subj: Standards for Sub-panels and Small Instruments

In reviewing the "Letter to the Editor" by Mr. Harry G. Bangerter (in the June issue, *I&A*) we have assumed that his discussion is concentrated primarily around basic indicating instruments. The following sketch and table reflect our interpretation of the problem:



Small Panel		Opening	
W	H	W	H
5	6	4½	5½
8	7	7½	6½
8	11	7¼	10¼



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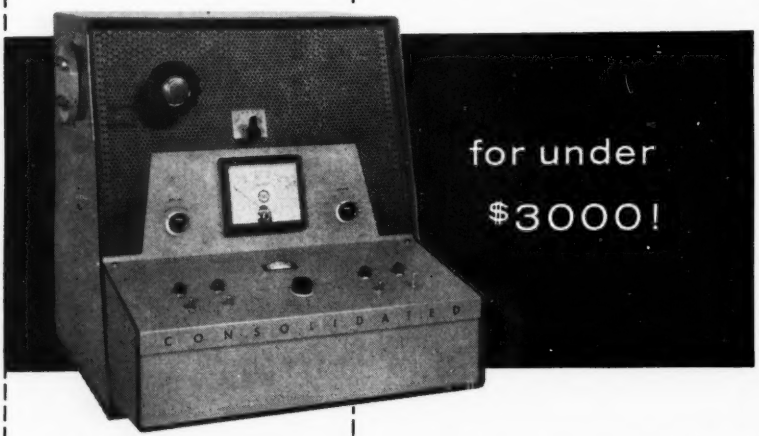

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LETTERS—CONTINUED

Main Panel W	Main Panel H	Insts./Panel
19	7	3
19	8¾	2
19	12¼	2

Since there has been a general standardization during the past few years on instrument sizes, we would suggest that the dimensions and data contained in ASA Standard C39.1-1955 be followed.

Of course, there will be instruments of special types which do not fall within these ASA Standard dimensions but it would be hopeless as we see it to try to include everything that is available from the industry.

R. K. Putnam
Sales Mgr., Electrical Instruments
Weston Electrical Instrument Corp.
Newark 5, N. J.

Editor, I&A:

I think that it would be a good idea to have some "standard" sizes for smaller instruments so they can be mounted in "special" panels for standard 19" relay rack panels.

We have little experience with customers who use our instruments in relay rack panels. I do know that when we are called upon to furnish a Simplytrol in a relay rack, there is a fair amount of waste space involved. Our bearing monitor could also be made smaller if there were some smaller panel that was a standard size.

John Saint-Amour
Assembly Products, Inc.
Chesterland, Ohio and
Desert Hot Spring, Calif.

Editor, I&A:

We have reviewed with interest the "Letter to the Editor" (June, *I&A*) from a man engaged at the test group instrumentation at Douglas Aircraft Company, pertaining to the consideration of adoption of a standard sub-panel size and standard sizes for small instruments.

This may be considered, in our opinion, in the nature of a "Utopia" condition, but one that would be very difficult to realize. Each manufacturer of test equipment has certain requirements that he desires to engineer into his product. These requirements will reflect themselves in the size of the particular device. In addition, for various reasons, each manufacturer feels that the particular dimensional configuration that he has given to his equipment is the most suitable for that purpose.

For these two reasons, we believe that it would be quite difficult to get all of our industry to agree that all equipment would be confined to certain dimensional sizes.

W. A. Beswick
Vice President
Phaostron Instrument & Electronic Company
S. Pasadena, Calif.

Editor, I&A:

We hereby submit our comments on the standard panel recommendations made by Harry G. Bangerter of Douglas Aircraft Company (in June, *I&A*).

Of the smaller instruments which we manufacture we feel that they all could be arranged to fit one of the standard sizes as suggested. If such standard sizes are eventually adopted by the industry we would probably consider redesign of our smaller instruments to accommodate such standardization.

It is our feeling in general that standardization such as proposed is beneficial both to the user and the manufacturer of the product and we would therefore be in favor of such changes.

John A. Pfingsten
Acton Laboratories, Inc.
Acton, Massachusetts

Editor, I&A:

With reference to your editorial, "Do You Know Your Instruments?" (March, I&A) I have the following comments:

1. I agree that knowing an instrument and its components thoroughly, as well as their characteristics, is very desirable. This is particularly true in the case of the technician who perhaps tries to carry out the desires of an engineer with an idea, but with a more general background.
2. I don't believe it is practical, for the Instrument Application Engineer, for example, to know each instrument and its components as intimately as you have suggested, and at the same time know what he should about the various processes and their characteristics so as to do a good job of Instrument Application Engineering. In other words, I believe it is desirable to have an Instrument Engineer with considerable savvy for the process, or a Process Engineer with sufficient instrument knowledge to be able to utilize the information that can be gained from more specialized personnel, such as manufacturer's representatives, or your own company's technicians. These are the ones, in my opinion, that should really know the instrument characteristics, inside and out.

In conclusion, it would be desirable to know everything about everything, but there just aren't that many hours in a day.

Glen G. Gallagher
Principal Instrument Engineer
The Fluor Corp., Ltd.
Los Angeles 22, Calif.

Editor, I&A:

Shortly after I entered the U. S. A. in November, 1954, I saw your magazine for the first time and I have been reading it ever since. It is a wonderful publication, which gives me a lot of information.

In your May '56 issue, (Inquiries A-90, P. 823) one of your readers seeks a tape recorder for a special application.

I do not know whether the one I know is available, but it certainly will meet your reader's specifications: The recorder I have in mind is the AEG-type KL 25, (made in Germany), a portable machine with built-in amplifier; speaker; double speed; double track; a foot pedal for stop-record-run back and microphone. This recorder has a very good reputation in Europe and is sold in Holland for approximately $300.00. (Will be somewhat higher here).

Edward J. Cator
Product Development Engineer
Crawford Fitting Co.
Cleveland 10, Ohio

Thank you, Edward, for taking time to assist a fellow engineer with a problem—and for letting us know what you think of our work.

Editor, I&A:

Your tutorial article on CTC and the generalization of its meaning to Centralized Transport Control in May *Instruments and Automation* proved most interesting to me. However, credit should be given to Mr. G. E. Fenimore of the CAA at Indianapolis for the portion on *Air Traffic Control;* this portion of your article is similar to material in his AIEE Transactions paper of May, 1955.

The caption of your Figure 16, also from Mr. Fenimore's paper, incorrectly ascribes the magnetic drum storage to another manufacturer. Actually, the magnetic drum storage and processing equipment was devel-

Miniature Pressure Transducers

STATHAM UNBONDED STRAIN GAGE TRANSDUCTION

MINIMUM RESPONSE TO VIBRATION OR ACCELERATION

TEMPERATURE COMPENSATION OVER 315° F. INTERVAL

20 MILLIVOLTS AT 5 VOLT EXCITATION

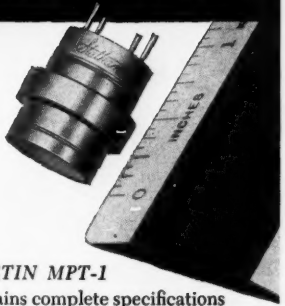
PRESSURE ADAPTERS FOR CLOSED LINE APPLICATIONS

HOMOGENEOUS SENSING DIAPHRAGM SURFACE

NO EPOXY RESIN PRESSURE SEALS

MAXIMUM LINEARITY

ABSOLUTE PRESSURE
0-5 to 0-150 PSIA . . . MODEL P130
DIFFERENTIAL PRESSURE
±2.5 to ±25 and 0-5 to 0-150 PSID . . . MODEL P131
GAGE PRESSURE
0-5 to 0-150 PSIG . . . MODEL P132



BULLETIN MPT-1
contains complete specifications on the foregoing pressure transducer models.

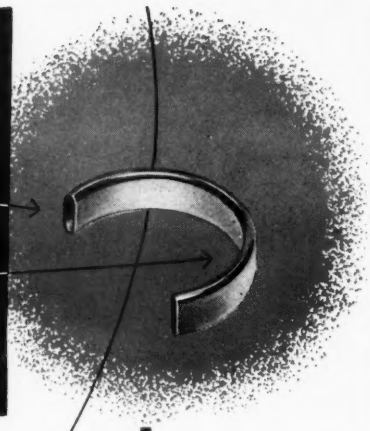
All matters pertaining to sale or use of instruments of our manufacture are handled by engineering personnel directly from our Los Angeles plant.

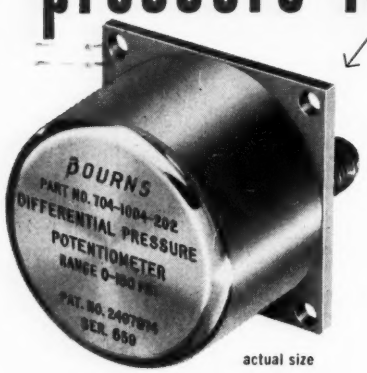
Please feel free to wire or telephone us collect whenever we may be of service.

Statham
LABORATORIES
1240L W. Olympic Blvd., Los Angeles 64, Calif.

For more information circle **8** on inquiry card.

BOURNS new Bourdon tube pressure transducers

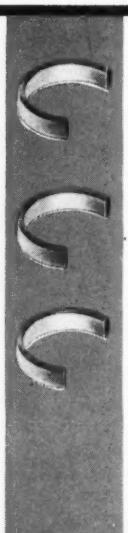




actual size

—a complete line designed for high range— with stainless steel or beryllium copper construction.

Bourns—designer and manufacturer of its own Bourdon tubes—now brings this proved component to absolute and differential pressure potentiometers. Three instrument models are provided for an extensive range of applications.



Model 704
Differential Pressure Potentiometer—*for corrosive fluids*
This unit has a stainless steel Bourdon tube and fittings, to withstand fuming nitric acid and other corrosive fluids. All mechanical joints are Heli-arc welded. The instrument will measure differential pressure between two high pressure sources.

Model 705
Absolute Pressure Potentiometer
This absolute pressure potentiometer measures pressures in ranges of 0-100 to 0-1000 psia—extending the range of Bourns' Aneroid Capsule instruments.

Model 706
Differential Pressure Potentiometer—*for non-corrosive fluids*
The Bourdon tube in this high range instrument is made of berryllium copper for use with non-corrosive fluids. With the low pressure port vented to the atmosphere, this unit can be used as a gage pressure instrument.

All models have a durable stainless steel case... compact configuration... excellent linearity, resolution and hysteresis. The rugged linkage system and Bourdon tube assembly provide excellent shock, vibration and acceleration characteristics. All models are now in quantity production. Write for new literature.

COPR. BL

BOURNS LABORATORIES
General Offices: 6135 Magnolia Avenue Riverside, California
Plants: Riverside, California—Ames, Iowa

For more information circle 9 on inquiry card.

LETTERS—CONTINUED

oped and built by Remington Rand Univac at St. Paul.

This equipment was installed at Indianapolis in August, 1953 and has operated continuously ever since. The Teletype switching system was installed shortly after the storage equipment, and the data transfer and display equipment more recently. The latter equipment is described by Fenimore in the AIEE Transactions, Volume 74, Part I, May, 1955, pages 145-149. The storage and processing equipment is described by me in the same issue of the Transactions, pages 152-155, and also in *Electrical Engineering* for May, 1955, pages 374-377.

Robert M. Kalb
Remington Rand Univac
St. Paul W4, Minn.

The two paragraphs and one illustration in question did indeed originate from Mr. Fenimore's AIEE paper, and we are pleased to make public acknowledgement of it. The authors apologize for the mistake in attributing the Remington Rand magnetic drum storage and processing equipment to Teleregister. Both firms, of course, are leaders in the field of traffic-data handling.

Editor, I&A:

I have just completed reading your May issue of *Instruments and Automation* and am highly impressed with the unique coverage you have of this field. Keep up with the good work as a quality magazine such as *I&A* is indispensable in this industry. Although our laboratory receives *I&A*, I would like to enter subscriptions for myself and another staff member so that we may benefit from a personal file of your fine magazine.

Frank P. Serio
University of Illinois
Urbana, Illinois

Both personal subscriptions to the home and company subscriptions to the office are, of course, important. However, it is important to note their difference. The latter are usually circulated more widely but read less thoroughly. The highest compliment we can receive is the above—personal subscriptions from you who already have company subscriptions or who see *I&A* only via circulation within a plant or laboratory.

Editor, I&A:

Re your March 1956 editorial "Do You Really Know Your Instru-

ments," I can't help having the feeling that you are expecting too much of the instrument fraternity when you ask them to know the most intimate details concerning the wide variety of instruments available today. Instrument manufacturers maintain staffs of engineers because one group will specialize on one particular kind of instrument, e.g., electronic null balance instruments, and will know just about all there is to know about this particular type, while another group will specialize on certain control systems, other types of instruments, etc.

The field of instrumentation is already so broad and enlarging so rapidly that the instrument engineer employed by the consumer has to be on his toes just to keep up with current instruments and has practically no time to learn the finer details of their operation.

Since this is the era of accomplishment by teamwork, it seems practical to include the specialists of the instrument manufacturer on the team.

C. I. Glassbrook
Stanford Research Institute
Menlo Park, Calif.

Editor, I&A:

Since the August 1955 issue of *Instruments and Automation* I have been following eagerly the letters column regarding the famous editorial "Automation and Culture." It was indeed a masterpiece.

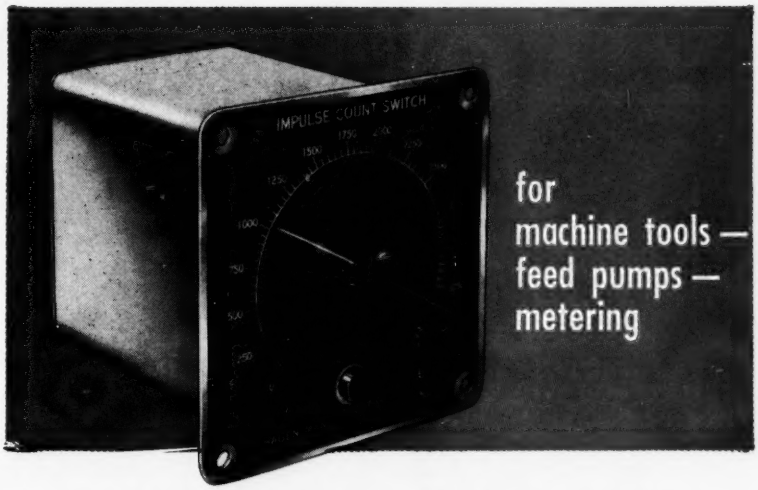
I have no comment on that editorial just at the moment but I am mailing you under separate cover some samples of "Poetry for the Instrument Engineer." Your March 1956 letters column suggested that contributions would be awaited, so here are some!

The collection "Tales Without End" is an attempt to put into rhyme, and to commemorate, some memorable incidents and personalities I know about here at the Lycoming engine plant here in Williamsport, where some of us are working on Gas Turbine Compressors. I am in charge of the section . . . (There also) is a Song of Instruments which tells the tale of troubles with a defective manometer bank; also a Sonnet to Calibration which might be suitable.

Clifford B. Haughton, Jr.
Montgomery, Penna.

We find these poems a sensitive reflection of the problems and emotions of "instrument engineers." You will find one of Mr. Haughton's poems on page 1305 of this issue. Others will be published in the future.

HAGEN count switch



PAID FOR BY SAVINGS MADE ON JUST 1 TOOL

Simply set this Hagen Count Switch to the number of operations at which a tool should be changed. The count switch trips a switch after a preset number of electrical impulses . . . and thereby shuts down the machine automatically. Tool wear never reaches the point where tools must be ground down excessively to resharpen. That means increased tool life, reduced tooling costs and fewer rejects. Compare the savings on just *one* tool with the cost of this reasonably priced Hagen Count Switch. Chances are, the savings will be much greater.

This Hagen Model 70 Count Switch has 72 dial divisions . . . 72 possible settings. Dials are available with up to 54,000 counts. Accuracy: 1% of full scale range. Ideal for feed pumps and metering operations. Send coupon for Bulletin 780 — or data on the complete line of reset and repeating cycle timers and counters, interrupters and control assemblies.

MAIL COUPON TODAY!

HAGEN MANUFACTURING COMPANY, INC.
Dept. IA-756, Moline, Illinois

☐ Please send free Bulletin 780 on Hagen Count Switch.
☐ Send free data on counters, timers, interrupters and control assemblies.

NAME AND TITLE
COMPANY
ADDRESS
CITY ZONE STATE

For more information circle **10** on inquiry card.

How to simplify

The Bailey Building Block Method enables you to simplify control problems by combining standardized measuring, transmitting, and controlling components as required.

For more information circle **11** on inquiry card.

control problems

Keep systems flexible, carry small inventory, cut maintenance cost with the **Bailey Building Block Method** of instrumentation and control.

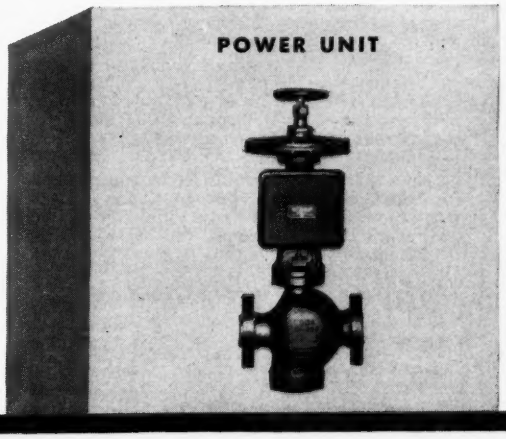
What is the Bailey Building Block Method? It's using standardized Bailey measuring, transmitting, and controlling components and combining them into any system you need. Components can be added as needed . . . removed and reused elsewhere . . . recombined into another system when the need changes. It's flexibility plus!

It's all based on the simple fact that a Bailey instrument or control component doesn't care if the measured variable is steam flow, tank level, or heater temperature, to pick just three examples. System components—transmitters, receivers, relays, selector stations, power units—are standardized for multi-purpose use.

A spare component can be used in any one of many systems. Gone are delays waiting for shipments of special parts. Gone are large inventories of spares and parts. Simplified is the training of men for maintenance.

There are many exclusive features and advantages of the individual components used in the Bailey Building Block Method. And there's much more to the Building Block story itself.

For further details, call our local district office or write us at Cleveland. Our engineers will be glad to prove how the Building Block approach will save you money and simplify your instrument and control problems.



BAILEY BUILDING BLOCK METHOD

BAILEY METER COMPANY
1041 IVANHOE ROAD, CLEVELAND 10, OHIO
In Canada—Bailey Meter Company Limited, Montreal

RESULTS IN: FLEXIBILITY, SIMPLICITY, ECONOMY

BAILEY METERS

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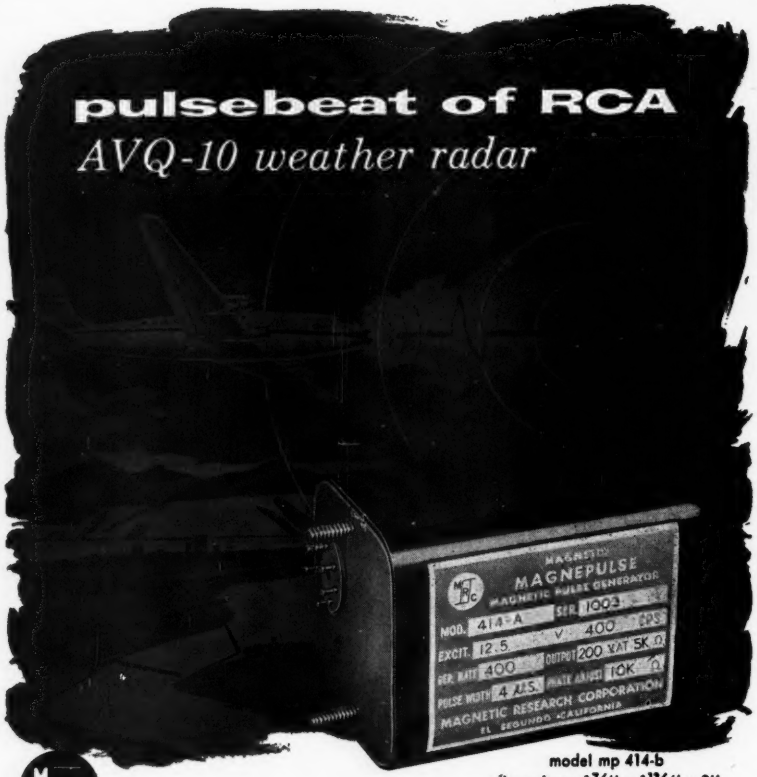


model mp 414-b
dimensions: 1⅞" x 1 13/16" x 3"
weight: 14 ounces

pulsebeat of RCA
AVQ-10 weather radar

MAGNEPULSE
all-magnetic pulse generator

IN LOOKING for a pulse generator to meet the rigid performance requirements of AVQ-10 radar, RCA engineers insisted on extreme compactness and outstanding reliability. They found these qualities in the MAGNEPULSE MP 414-B.

Used as a trigger generator for hydrogen thyratrons, this tiny unit provides an unfailing "pulsebeat" for AVQ-10 radar as it "looks into" the weather to increase reliability and comfort of commercial airline and business aircraft. The MP 414-B replaces approximately four electron tubes.

Here are more reasons why RCA chose the MAGNEPULSE MP 414-B:

- Unit is hermetically sealed.
- Uses only 1 watt of power.
- Operates on standard 400-cycle aircraft supply.
- Provides pulse of 250-volt peak into 500 ohms resistive load.
- Pulse repetition rate: 400 pps.
- Pulse width: 4.5 microseconds.
- Ambient temperature: −40 to +100° C.
- No tubes, no moving parts, no warm-up time.
- Short-circuit proof — no protection circuits required.

High-power, all-magnetic pulse generator units are available in power ranges from .1 to 10 megawatts to replace conventional hydrogen thyratron pulses in radar systems. Excellent performance in digital computer applications, too.

write for EB 204 Magnepulse bulletin

MAGNETIC RESEARCH CORP.
200 CENTER STREET • EL SEGUNDO, CALIFORNIA
Mfrs. of Magnetic Amplifiers and Converters, Magnetically Regulated DC Power Supplies, Magnetic Pulse Generators.

For more information circle **12** on inquiry card.

Inquiries

These inquiries, representing problems facing readers of **Instruments & Automation,** are published as a free service to our readers.

Ultrasonic Cleaner

Manufacturers' representative (electrical measuring, protective and control apparatus) seeks source of supply for ultrasonic cleaner of one or two pint capacity. A-110

Electronic Printing

Reader seeks information on electronic printing methods, such as smoke printing, electrography, xerography and electromagnetic dry printing. A-111

Computer Component Circuits

Reader seeks book giving circuits of computer components in simplified form, for instance adding, multiplying, etc., not block diagrams. A-112

Glass Blowing

University Library is interested in subscribing to a magazine dealing with glass blowing and laboratory techniques. A-113

Solenoid

Manufacturer of chemicals seeks source of supply for 1½-lb air-cushioned solenoid for 110-volt 60-cycle operation. A-114

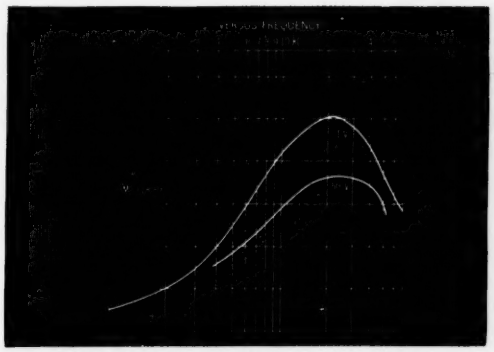
Mercury Switch

Engineering Coordinator of company manufacturing aircraft instruments and gyro devices seeks source of supply of miniature mercury switch capable of operating between minus 65 and plus 200° F, and handling 125 milliamps dc at 28 volts. A-115

Small Air Valves

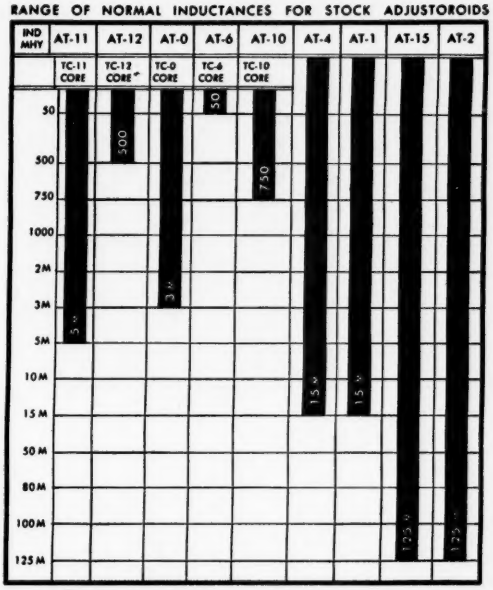
Project Engineer in plastic products company seeks sources of supply for small sequence valves, relief valves, and pilot-operated valves for air, with ⅛" NPT (or ¼" NPT) connections, of light construction, to be used in portable equipment. A-116

variable "L" by BURNELL



Typical Q vs. frequency characteristics of Adjustoroids.

RANGE OF NORMAL INDUCTANCES FOR STOCK ADJUSTOROIDS



For nominal D. C. R. values refer to Burnell catalog No. 103.

ADJUSTOROIDS®

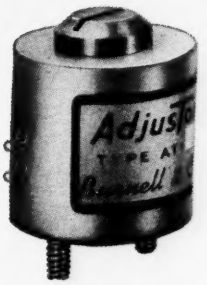
The Adjustoroid, a low cost adjustable toroid, exclusively developed by Burnell & Company, Inc., contains an actual complete toroid with all the excellent characteristics of the non-adjustable types. Adjustment is obtained by a completely stepless function with magnetic biasing.

The nominal inductance value for an Adjustoroid is the **maximum** value, and the inductance range is the nominal value minus approximately 10%.

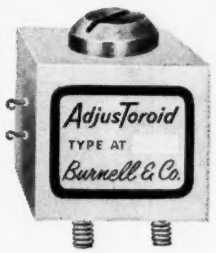
Hermetically sealed to meet Government MIL specifications. Many types of networks in tuned circuits are being produced which employ the Adjustoroid in completely hermetically sealed packages.

Intermediate inductance values as well as special taps and extra windings available on special order with minimum delay.

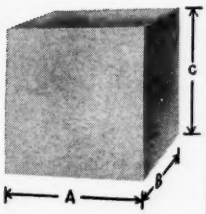
For additional technical data on Adjustoroids, refer to equivalent toroid in catalog.



AT-0, AT-6, AT-10, AT-4



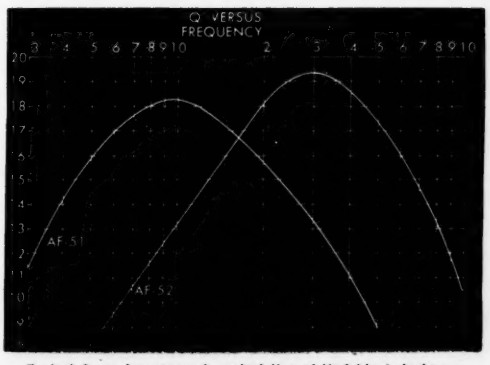
AT-1, AT-2, AT-11, AT-12



ADJUSTOROID & VARIABLE INDUCTOR DIMENSION CHART

	A—LENGTH	B—WIDTH	C—HEIGHT
AT-O, AT-6	1-1/16"		1"
AT-10, AT-4	1-19/64"		1-1/4"
AT-15	1-31/32"		1-7/8"
AT-11, AT-12	45/64"	45/64"	3/4"
AT-1	1-3/4"	1-3/4"	1-1/4"
AT-2	2-3/4"	2-3/4"	2-1/4"
AF-51, AF-52	1-19/64"		2"

and now . . .



Typical Q vs. frequency characteristics of Variable Inductors.

VARIABLE INDUCTORS

AF-51 AF-52

(20-500 cycles)
Maximum Q at 100 cycles

(50-1000 cycles)
Maximum Q at 250 cycles

Burnell Variable Inductors have the similar characteristics to the Adjustoroid except they are especially designed for low frequency applications or for conditions where high inductance values are required. Variable Inductors are available in all inductance values up to 1000 Hys.

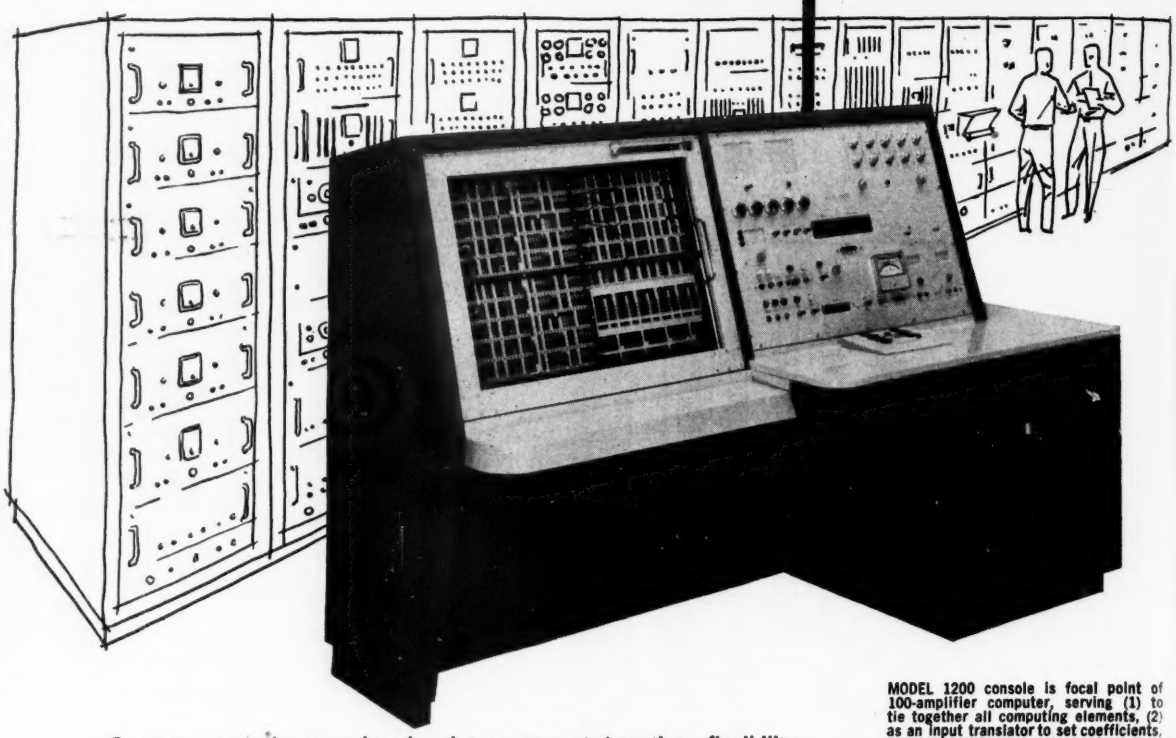
BURNELL & CO., INC.
YONKERS 2, NEW YORK Teletype: Yonkers, N. Y. 3633
Pacific Division: 720 Mission St., S. Pasadena, Calif.

For more information circle **13** on inquiry card.

Get Tomorrow's Higher Standards for Convenience and Accuracy Today

with NEW EASE*

1200 SERIES
ANALOG COMPUTERS



MODEL 1200 console is focal point of 100-amplifier computer, serving (1) to tie together all computing elements, (2) as an input translator to set coefficients, initial conditions, constants from keyboard or punched tape, (3) as output source for analog and digital recorders, (4) as checking device to detect wiring or pot-setting errors, (5) as control point for switching, timing operations, and for indicating circuit amplifier overloads or circuit malfunctions, (6) switching point for all primary power. 3600-terminal patchboard is color-coded for simplified problem patching.

Operator convenience, reduced maintenance and downtime, flexibility and accuracy far beyond today's standards are important advantages offered in EASE* 1200 series console-operated computers.

Specific features include:

1. **Complete keyboard control of all problem parameters including initial conditions and coefficients**
2. **Automatic punched tape or card attenuator setting**
3. **Complete and automatic digital recording of all problem parameters**
4. **Built-in static and dynamic problem checking system**
5. **Built-in 6-channel chart recorder, or electric typewriter with punched tape readin—readout equipment**
6. **Completely shielded patch cord and patch board system**
7. **"Human engineered" centralized console design**
8. **Instantaneous and "stored" overload indication**
9. **Unitized design for complete flexibility and future expansion**
10. **.01% accuracy—not only in passive elements, but also featuring the ability to set gains completely through amplifier to better than .01%**

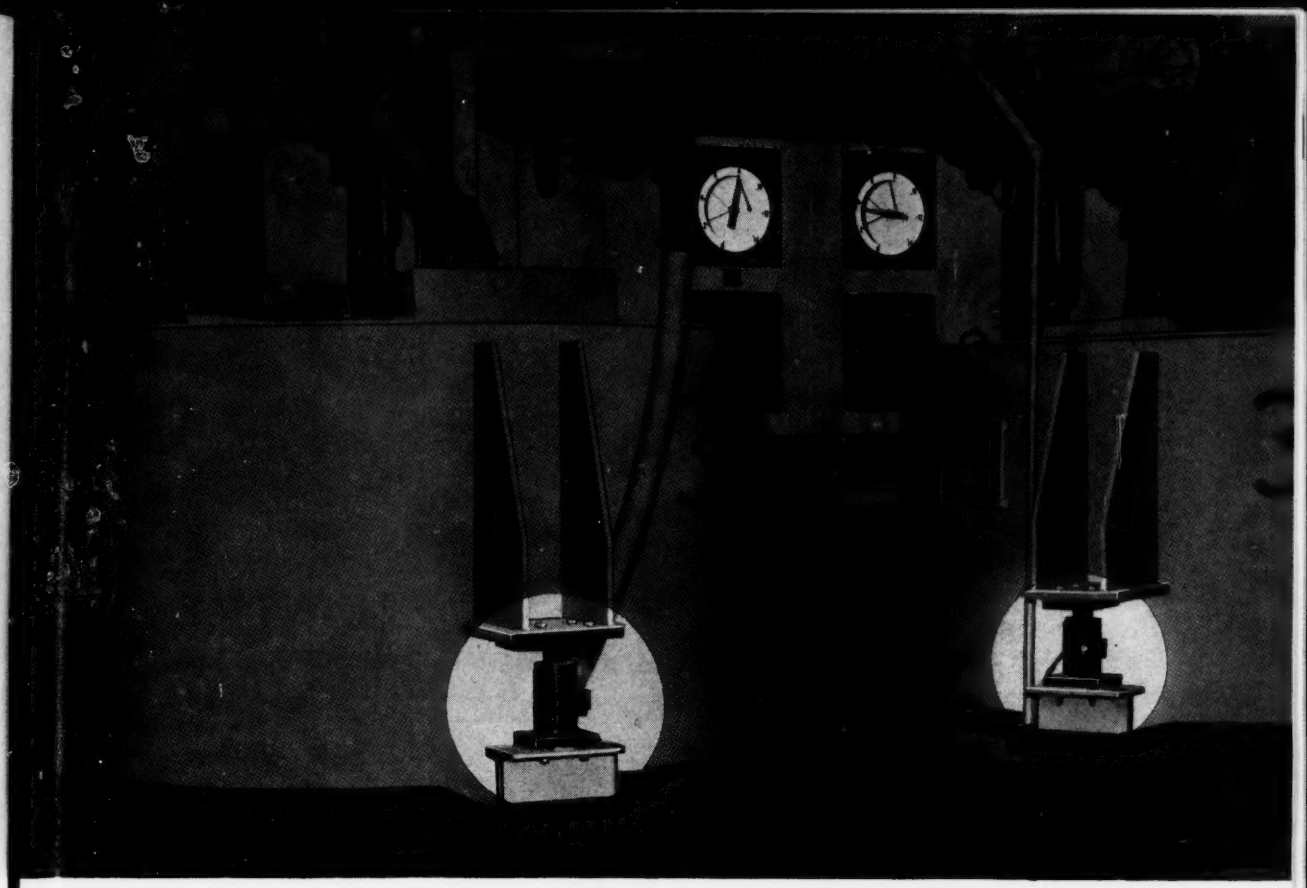
These are, of course, but a few of the many advanced-design features that make "Do it with EASE*" more than just a slogan. Complete descriptive and technical data will gladly be sent on request; please address Dept.. B-6.

See us at the WESCON Show
Booths 718-719

Berkeley division
BECKMAN INSTRUMENTS INC.
Phone: LAndscape 6-7730
Richmond 3, California

*TM for Electronic Analog Simulation Equipment by BERKELEY

For more information circle **14** on inquiry card.



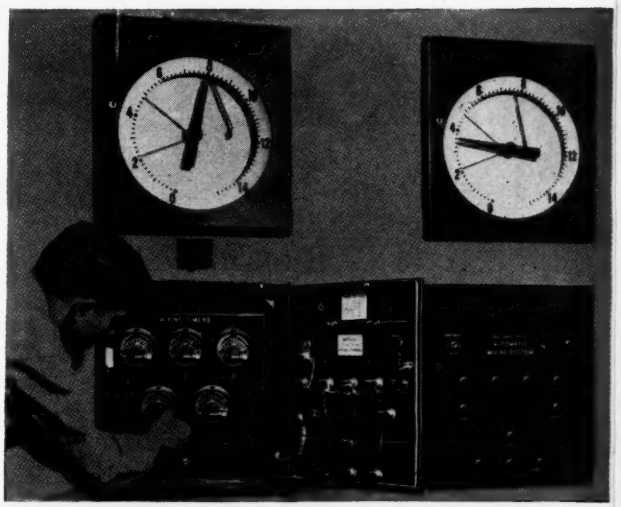
Compact Baldwin SR-4 sealed load cells mount conveniently below tank flanges.

simple, maintenance-free Baldwin SR-4® system proportions 5 ingredients to ±1/10% repeatability

Automatic proportioning of liquid and solid ingredients is achieved in this chemical process by an integrated Baldwin SR-4 system.

Baldwin SR-4 transducers weigh each ingredient as it is added to the batch. The load cells transmit signals to the indicator-controller, automatically opening and closing supply tank valves as required by the formula. This closed loop system is instantaneously responsive and highly accurate.

You can have a Baldwin SR-4 electronic control system, specifically designed for your needs, for any application involving weight, pressure, tension, torque or thrust. We engineer the entire system and calibrate it as a unit, to guarantee you maximum accuracy. For your copy of bulletin 4302, write Dept. 2853, Electronics & Instrumentation Division, Baldwin-Lima-Hamilton Corporation, Waltham, Massachusetts.



Baldwin SR-4 instrumentation for automatic batching includes an indicator-controller-recorder and timer system for each tank.

BALDWIN BLH LIMA-HAMILTON

ELECTRONICS & INSTRUMENTATION DIVISION
BALDWIN-LIMA-HAMILTON

DIVISIONS: Austin-Western • Eddystone • Hamilton • Lima • Electronics & Instrumentation • Madsen • Loewy-Hydropress • Pelton • Standard Steel Works

For more information circle **15** on inquiry card.

LEWIS

HIGH TEMPERATURE MOISTURE and FIRE RESISTANT ELECTRICAL CABLE *for AIRCRAFT*

to MIL-C-25038

FOR SUPERIOR WET DIELECTRIC STRENGTH, ABRASION RESISTANCE, HIGH TEMPERATURE AND FIRE RESISTANCE, AS WELL AS RESISTANCE TO OIL, FUEL, HYDRAULIC FLUID AND SALT WATER —

USE *LEWIS* HT CABLE FOR CRITICAL CIRCUITS

AVAILABLE IN AWG SIZES FROM #20 TO #4/0

AWG	AWG	AWG
20	10	1
18	8	0
16	6	00
14	4	000
12	2	0000

WE MAKE CABLE TO DO SPECIFIC JOBS. TELL US ABOUT YOUR PROBLEM.

SPECIFY *LEWIS* MIL THERMOCOUPLE WIRE
FOR PERMANENT AIRCRAFT INSTALLATIONS

CORRECTLY CALIBRATED TO INSURE AIRCRAFT ACCURACY AND WITH LEWIS LAMINATED INSULATION TO MAINTAIN CIRCUIT INTEGRITY

MIL-W-5908A

COPPER-CONSTANTAN
THERMOCOUPLE WIRE AND LEAD WIRE
TYPE I CLASS A, B, C, D, E, F AND G
TYPE II CLASS A AND B
TYPE III CLASS A AND B
TYPE IV CLASS A AND B
TYPE V CLASS A AND B

MIL-W-5846A

CHROMEL-ALUMEL
THERMOCOUPLE WIRE AND LEAD WIRE
TYPE I CLASS A, B, C, D AND E
TYPE II CLASS A
TYPE III CLASS A
TYPE IV CLASS A

MIL-W-5845A

IRON-CONSTANTAN
THERMOCOUPLE WIRE AND LEAD WIRE
TYPE I CLASS A, B, C, D, E, F, G, H, I AND J
TYPE II CLASS A, B AND C
TYPE III CLASS A, B AND C

PRODUCED IN OUR OWN WIRE MILL, LEWIS THERMOCOUPLE WIRE AND LEWIS HIGH TEMPERATURE ELECTRICAL CABLE ARE BUILT TO MEET AND IN MANY CASES EXCEED, THE RIGID SPECIFICATION REQUIREMENTS.

Write for Wire Products Catalog No. 953

THE LEWIS ENGINEERING CO.
NAUGATUCK, CONNECTICUT

For more information circle **16** on inquiry card.

INSTRUMENTS and AUTOMATION Trends

Iron curtains are crumbling at the scientific level, IGY (International Geophysical Year) Program for 1957-58 is wonderful example of international cooperation, underway on word-wide scale. Forty nations are cooperating. USA will fire hundreds of rockets, studying atmospheric structure and composition, radiation and particle phenomena, and making ionospheric and geomagnetic measurements. Other countries will do likewise. Highlight will be launching of earth satellite (Project VANGUARD, a joint Army-Navy-Air Force program under the direction of J. P. Hagen, Naval Research Labs) sometime between July, 1957 and December, 1958. Its instrumentation will be made known and results published for scientists of all nations. This is another example of now obvious trend away from secrecy and hostility between scientists of all nations; I&A now goes behind the iron curtain; Russian journals now come here. The IGY represents the greatest single act of cooperation ever taken by scientists of all nations, as well as the most extensive examination of the earth's environment.

Airline passenger traffic is increasing spectacularly—165% between 1946 and 1954, reports CAA. Rate of growth has exceeded 10% per year for last 6 years. Hence CAA forecasts a growth of 3.8 million passengers per year, to from 32 million in 1954 to estimated 55 million by 1960, and 70 million by 1965.

AIR FORCE strength has grown from 42 wings in 1949 to present 121 wings. Sixteen wings will be added in next 2 years to reach authorized level of 137 wings manned by 975,000 officers and men. Military budget in 1956 for air purposes was $32 billion, of which Air Force received $16.5 billion. Instrumentation is key element at every phase of aviation.

Cost of fuel for power varies widely in USA-from about 10 cents/million BTU (about 1 mil per kw-hour for fuel) in parts of Texas to more than 35 cents per million BTU (about 4 mils per kw-hour) in parts of New England. Note: even "high" 4-mil fuel cost is much lower than any possible power from nuclear sources. May be 10 years for nuclear power to become economically competitive in USA; 5 years in Britain; less in other foreign areas.

Ownership and control of entire field of nuclear power generation is in state of transition—from full Government control to private industry control. More than 500 private firms have been accorded access permits for obtaining classified information on civilian uses of atomic energy.

BRISTOL'S
INSTRUMENTATION

BRISTOL ELECTRONIC DYNAMASTERS will measure and automatically control any variable — from temperature to viscosity

ANY VARIABLE that can be translated into an electrical quantity – temperature, pressure, pH, voltage, speed, smoke density, resistance, and hundreds of others – can be measured, recorded, and automatically controlled by Bristol's Electronic Dynamaster® Potentiometer and Bridge instruments.

Whatever your measurement or automatic control problem may be, whether it be in the plant, laboratory, or pilot plant, there is a Bristol Electronic Dynamaster for it.

ADVANTAGES of the Bristol Electronic Dynamaster:

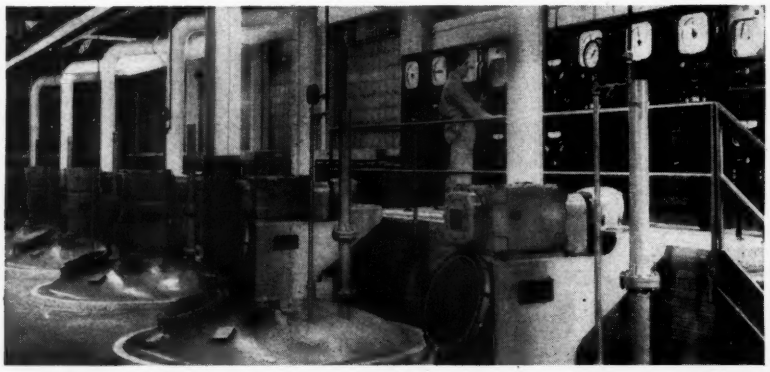
1. Continuous standardization with no dry cells, eliminates need for dry cells and standardizing mechanism – Results: no interruption to control, no batteries to replace.
2. High accuracy . . . fast operation . . . continuous electronic measurement.
3. Simple in design . . . few moving parts.
4. Easy to use and service . . . little or no maintenance required.
5. Flexible in application.
6. Rugged in construction . . . especially built for industrial plants, pilot plants, and for research and laboratory use . . . unaffected by vibration.
7. Plant operating men quickly become familiar with this instrument and like to use it.

MODEL FOR EVERY REQUIREMENT. Dynamaster Potentiometers and Bridge Instruments are available as single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments and as round-chart instruments.

ELECTRIC AND PNEUMATIC CONTROLLERS. Both strip-and round-chart instruments are made in a very wide variety of controllers that meet every control requirement, including the following in a great many forms:

Electric Control – on-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control – on-off, proportional, proportional with reset, and proportional with reset and derivative.



LIQUID LATEX TEMPERATURE is controlled precisely to remove ammonia from natural latex prior to foaming in this plant.

Automatic plant uses Bristol's Dynamaster Instruments

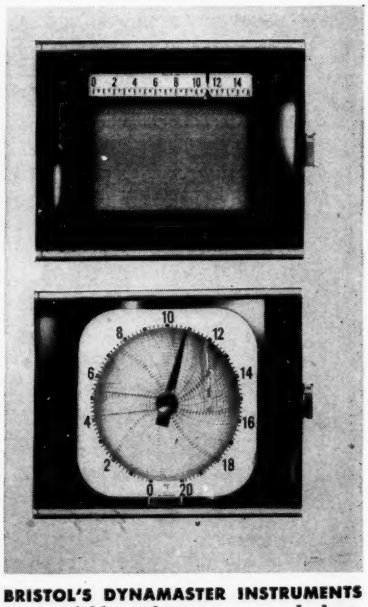
Automation is a reality here at the Buffalo Foam Rubber Products plant of the Dunlop Tire and Rubber Corporation. This automatic plant, designed and built by Mechanical Handling Systems, Inc., Detroit, uses Bristol Dynamaster Electronic Instruments and Automatic Controllers as part of a process employing today's most advanced automatic production techniques. The result – greater efficiency and productivity, lower costs, improved product.

For more information circle **17** on inquiry card.

Sun Oil Plant uses Dynamaster Recorders

Dynamaster Multiple-Point Temperature Recorders are used in the Control Room of the huge new 15-million-dollar Petrochemical Plant of Sun Oil Company at Marcus Hook, Pa. The plant produces chemical grade benzene, toluene, and xylenes.

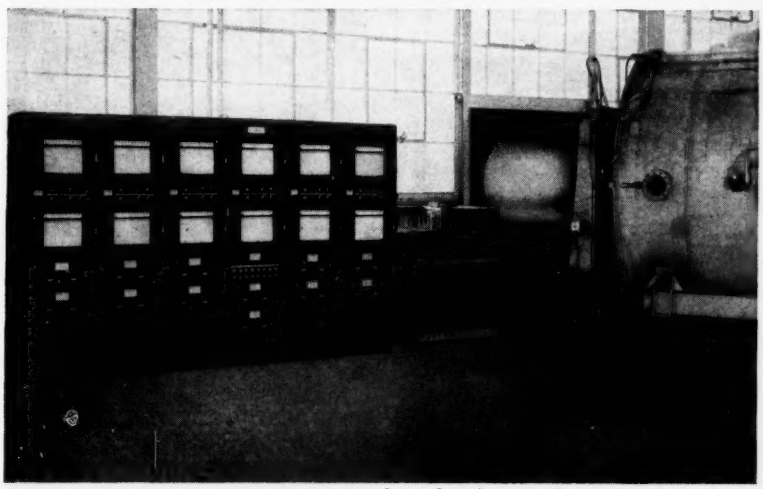
Some of the instruments shown measure the temperatures of feed stock into and out of heaters, at dozens of points. Others record temperatures in cylindrical reactors, where the petroleum molecules are rearranged (reformed) in the presence of the platinum catalyst.



BRISTOL'S DYNAMASTER INSTRUMENTS are available with strip or round chart. Same instrument except for chart drive.

NEWS

. . . news and information about automatic controlling, recording and telemetering instruments from Bristol . . . leaders in human-engineered instrumentation



BRISTOL'S DYNAMASTER INSTRUMENTS record test data from wind tunnel (right) and feed information to card punching machines at United Aircraft's Research Dept.

Bristol's Dynamaster Recorders feed analogue-to-digital converters

At United Aircraft Research Dept., Bristol's Dynamaster Recorders not only supply high-speed chart records of wind tunnel tests but feed analogue-to-digital converters that punch test data on cards, at 100 cards per minute, for analysis by electronic computers.

Dynamasters in this installation record the output of strain gauge pick-ups placed on test models in the wind tunnel. The models are subject to air at supersonic-velocities.

High-speed Dynamaster Recorders (1-second full-scale pen travel) inform test operators of test conditions *between* card punchings. Since the test only lasts from 10 to 20 seconds, it is vital that every bit of information be gathered for analysis.

Dynamasters aid gas dispatching in Midwest

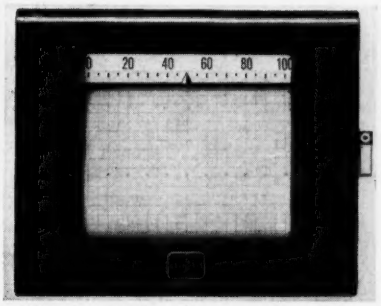
Bristol Dynamaster Metameter Telemeters, at a large midwestern gas utility, help gas dispatchers route gas throughout their distribution system.

These strip-chart Dynamaster Metameter Telemeters record gas pressure at strategic points in the system. This information used to be called in periodically by field men—a slower and less accurate process.

Using the continuous, accurate, up-to-the-minute information supplied by the wide-strip telemeter receivers, the gas dispatcher effects much better pressure regulation in the gas supply than with the old system—particularly during periods of unexpected demand.

New high-speed electronic Dynamaster Recorder

0.4-second for full scale pen travel



NEW 0.4-SECOND Dynamaster recorder

Freedom from overshoot on long or short traverses is a key feature of Bristol's new high-speed Dynamaster Recorder.

This high-speed instrument sets new standards for chart recorders in the fields of rocket and jet-engine testing, wind tunnel measurements, automatic-machine-tool control, scientific laboratory testing and numerous industrial applications.

SPECIFICATIONS:

Speed: 0.4 second to within 0.25% of balance for full-scale step-response without overshoot.

Sensitivity: Dead band less than 0.1% of full scale.

Ranges: Minimum range of 1 millivolt d-c.

Chart: 12¼ in., 11 in. calibrated.

Chart Speeds: Up to 4 in. per second.

No matter what your measurement problem is, a Bristol Dynamaster Potentiometer or Bridge instrument will solve it for you.

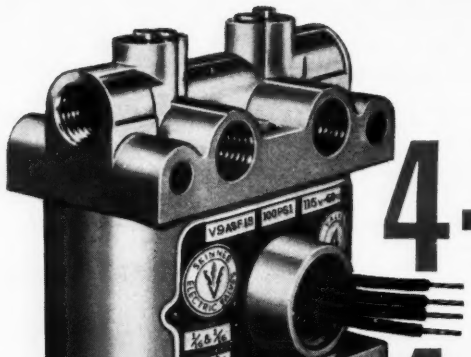
Write for all the facts

To get the whole story on these rugged, precision instruments, write today for your free copy of the 36-page bulletin P1245. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

5.24

.. WHAT'S NEWS AT BRISTOL... WHAT'S NEWS AT BRISTOL... WHAT'S

For more information circle **17** on inquiry card.



4-WAY for 4 REASONS

When you design or modernize equipment, look into the four big reasons for using Skinner's low-cost V9 Solenoid Valve. 1. Only 4 5/10" high, the V9 fits nearly anywhere, saves space, yet is powerful enough to operate single- and double-acting cylinders. 2. Available in more than 176 variations of capacities, metering and types; it can be used with air, inert gases, hydraulic oils and other common media at 0-150 p.s.i. 3. The V9 provides leakproof, dependable, *fast* operation — up to 600 cycles per minute in many applications. 4. Its rugged, frictionless construction and precision engineering ensure life spans of *millions of cycles,* eliminating replacement and maintenance problems.

For complete information, write for Catalog D2.

SKINNER SOLENOID VALVES

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116 Edgewood Avenue
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WORLD-WIDE REPRESENTATION

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How Tight Is Tight?

Panhandle Pete

BACK in the January issue of *I&A* was a letter to our Uncle Milton from Mr. John Kolesnick of Phila., Pa., it being one of complaint over the way this magazine is being run—too much impractical instrumentation, too many profound theories and even a prophesy of lost subscriptions unless things are changed. To all of which I add my amen! There is no doubt at all but what our Milton is living in the first half of the next century among the atoms and electrons. And this fellow John H. McLeod, Jr., who edits the *Simulation Council Newsletter* —did you ever read so much gastronomy? He reminds me of the story about the fellow who ate so many oysters that his stomach rose and fell with the tides. Where was I? Oh, Stimulation—this fellow writes several pages of, er, material which I'm sure is 'way over most of our heads. The only explanation for what goes on in this magazine, Mr. Kolesnick, is, in the words of Elbert Hubbard's definition of an Editor: a person employed on a magazine, whose business it is to separate the wheat from the chaff, and to see that the chaff is printed.

I have long considered writing a series of monographs entitled "Timely Tips for Tired Instrument Technicians," and for this month I am going to describe a repair operation pertaining to recording potentiometers: once in awhile these instruments will throw a violin string and the instruction books aren't too clear on one part of the operation. Anyone who has ever spent five minutes taking off all the control discs, auxiliary switches, pieces of old string, remembering to cut off ½" from one end of the new string part number R-25-D, splicing in a piece of shoestring and then after assembling all this stuff to have the string break or run off one of the pulleys because the spring-tension is wrong—well! I know of one man this happened to and he grabbed an ax and beat the instrument to pieces right then and there. So after I was re-instated on the job I spent no little effort in research on this subject and here for the first time is a sure-fire way to know when the violin string is tight enough. (I never begrudged myself the five minutes it took for the job, but I just hated to see others get so teed-off.)

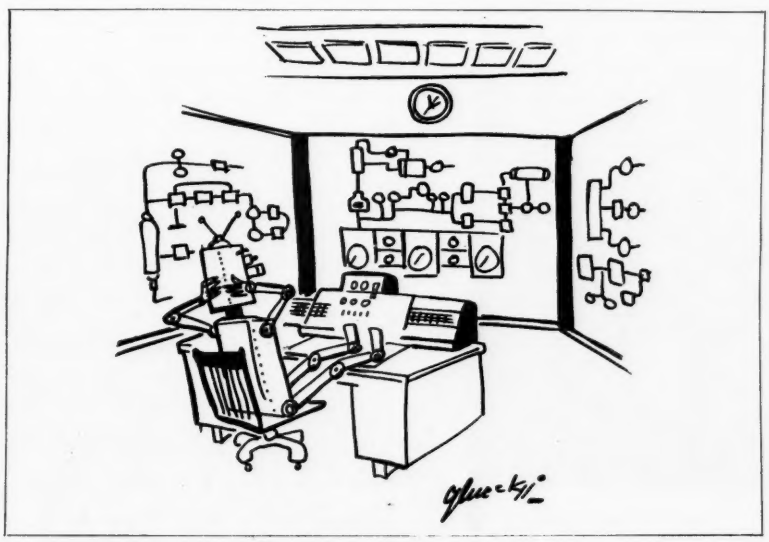
To give you D.R.'s an idea of what instruction books are like and the futility of words vs actions, here is a sample: "Insert the string through the hole W and draw it tight while holding lug L against the stop as directed in this paragraph . . . Insert the end of the string through the hole in lug M just far enough to hold while turning Lug M with a screw driver. Keep the string in the groove and turn lug M until the slack in the string is taken up . . . Insert the end of the string (the other end of the string from that discussed previously) from T in the hole of lug N and proceed as directed for the other end of the string tightening up on the screws K to hold lug N." Actually, when you are sitting down with this instruction book in one hand with the instrument propped up on a bench, a screw driver in your other hand, plenty of time to do this job and a pair of tweezers in another hand, why these instructions do not sound so ridiculous as they do in just reading them. (Editor's note—He just might have three hands.)

Isn't it easy to be an Instrument Man? Why sure, add to the above a money-hungry production man to look over your shoulder, a puddle of water to stand in, a hot tin stack to work alongside of and this five minute job becomes real hairy. The point is that the instruction book does not say how tight is *tight?* Down here in West Virginia we have people who learned to play guitars when they were kids so when they come into the mill and start on instruments they're all set: they can reach in and sorta pluck here and there and get perfect results. The rest of us ignorant people can't do this.

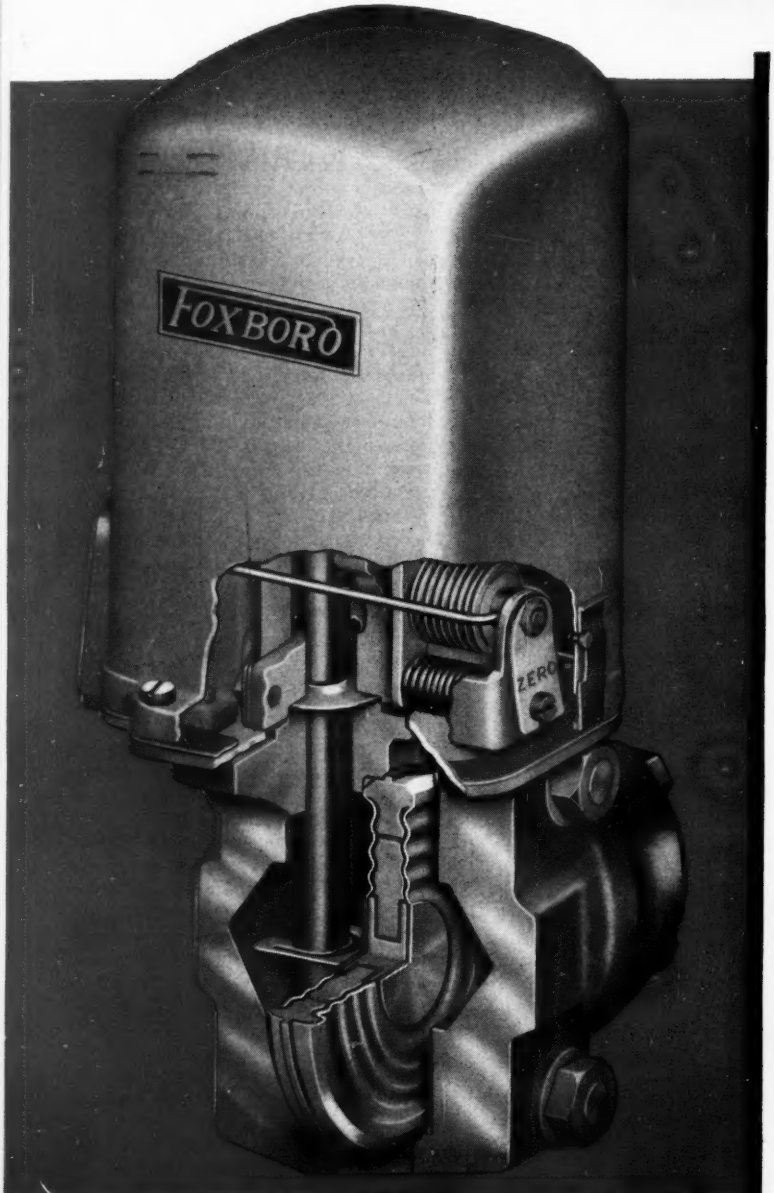
One day I am wandering around through town with one of these violin strings in my pocket, hunting a saloo—a music shop, when I came across this place, *Palumbo Music Salon, Violin, Vina, Viola da Gamba, Tuba and Violin-cello. Purina Farina, Prop.* Strangely enough this music store was right across the street from "Angelo's Pizza Shoppe, Light Wine and Beer." "Man," I thought, "If anyone knows about violin strings and how tight they should be here is the place to come." So I knocked on the door and soon an elderly white-haired gentleman opened the door and muttered "Yas?"

"Why I'd like to talk with Mr. Farina or Mr. Palumbo if either of the gentlemen aren't too busy," I started to ask when the old gentle-

Continued on page 1261



ONLY the Type 13A d/p C has these 6 advanced- d



- **Positive Overrange Protection** up to full 1500 lb. rating
- **Fully Adjustable Ranges . . .** 0-20" to 0-80" and 0-50" to 0-250" H_2O differential
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- **Highest Sustained Accuracy** . . . even under extreme operating and ambient conditions

With these basic features, plus many other technical refinements throughout, the new Type 13A d/p Cell* Transmitter surpasses all previous records in performance . . . economy . . . convenience. For the complete story and a demonstration, call your nearest Foxboro representative. Write for new Bulletin 13-11. **The Foxboro Company, 467 Neponset Ave., Foxboro, Mass., U.S.A.** Factories in the United States, Canada and England.

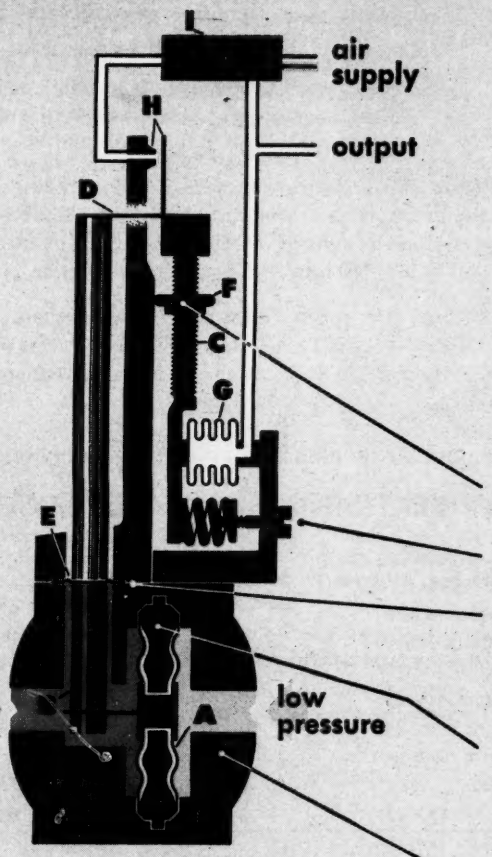
*Reg. U. S. Pat. Off.

More Foxboro flow transmitters are in use by the process industries than all other makes combined!

For more information circle **19** on inquiry card.

/p Cell Flow Transmitter

d-design features...



How It Works...

An increase in differential pressure across Twin-Diaphragm Capsule (A) exerts force to right on force bar (B). Elgiloy® diaphragm seal (E) acts as fulcrum. Force to left at top of bar (B) causes flapper to approach nozzle at (H). Resulting increase in nozzle pressure is amplified by relay (I). This pressure is sent to feedback bellows (G) which develops force to counterbalance the differential pressure on capsule (A). The 3-15 psi output signal from relay (I), always precisely proportional to differential pressure, is transmitted to remote recording or controlling instrument.

Range Wheel is continuously and easily adjustable for entire range whether 0-20" to 0-80" or 0-50" to 0-250" H_2O.

Easy-access screw adjustment permits field "zeroing" without removing weatherproof cover.

Elgiloy® stainless alloy diaphragm seal assures a corrosion-resistant, frictionless, positive pivot point. Instrument is constructed in 3 basic units — body, transmitter, and air relay block — eliminating all possibility of errors produced by piping stresses.

Silicone-filled Twin-Diaphragm Capsule filters out flow disturbances ("noise") at measurement source . . . without loss of speed of response. Precisely matched surfaces of diaphragms and capsule core provide "stops" which give positive overrange protection in both directions.

Rugged forged body, optionally Type 316 S.S. or carbon steel, gives greatest strength with least weight . . . ultra-compact design permits low cost mounting from flange taps.

FOXBORO
Reg U.S. Pat. Off.

First in Flow Instrumentation

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HELP YOURSELF TO A LARGER SHARE OF THIS GROWING MARKET

by advertising in the 1957 INSTRUMENTS & AUTOMATION HANDBOOK & BUYERS' GUIDE

(Formerly the I&A CATALOG & INDEX and the INSTRUMENT MANUFACTURING BUYERS' GUIDE)

Why dilute the effectiveness of your advertising in directories so general in scope as to eclipse the very market you are most interested in reaching?

INSTRUMENTS & AUTOMATION HANDBOOK & BUYERS' GUIDE is the *only* buying directory devoted *exclusively* to products and components in demand by this expanding instrumentation-automation market.

In the "Guide" pages of this annual directory, we list *your* products FREE . . . as a service to the buyers of instruments and automatic controls who use the directory through 12 months of product selection.

PAID DISPLAY ADVERTISING in this directory can help you compete more *effectually* for a larger share of the market by pinpointing valuable preselection data such as: product characteristics and specifications, special features, availability, etc.

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Fill in the space reservation below and send it t INSTRUMENTS PUBLISHING CO., 845 Ridge Av Pittsburgh 12, Pa.; or contact any of our district office

DISTRIBUTION: 25,000 copies

PUBLICATION DATE:
October 1956

CLOSING DATES:
For Copy and Cuts: August 15, 1956
For Complete Plates: August 31, 1956

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Type Page 7 x 10 inches
Halftones: 110 screen

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PANHANDLE PETE—CONT.

man broke in with "Well day ain't here. Meester Farina, hesa gone uppa town. Meester Palumbo, hesa go to work down tuh da meel. Justa me, Luigi Ginini isa here. Whatcha want?" So I handed him the violin string and asked him what it was and how tight should it be so it wouldn't break. Well sir, the old fellow got real excited and told me in voluble Italian, along with much gestering, something of importance, but all I could do was shrug my shoulders and raise my eye brows. Next came a demonstration on his violin. "See!" he shouted, "Thatsa your string. Hesa da one. You put him on and tighten up, and thatsa that." Luigi plucks the string and hits a note on his piano.

"But Mr. Ginini how much tension is on the string?" I asked again. "Watt you mean, dis tension, eh?" asked Luigi. So I started to explain what I meant by tension when Luigi exclaimed, "Oh mama mia! Tension, pounds, who knows? No wan tune that-a-way. Everyone tune this-a-way, see?" and he starts all over again.

Soon there is a muttering of "stupid fool, dumbhead" from Luigi, so after looking to see which key Luigi had tuned to I invited him over to Angelo's for a glass of wine to cool off with. The more I thought about it, and the more wine we drank, the more logical it appeared to forget about how tight the string should be in terms of pounds tension but rather judge tension in terms of pitch. Since Luigi had already tuned the string up to "A" (440) and a second trip to the Salon yielded the additional data that the length of the string on the violin was about thirteen inches, it was a simple matter to derive an equation: f equals 5720 L^{-1} V/sec and plot a curve with notes of the scale up the Y axis and string length along the X axis. All one has to do to get these instrument strings tightened correctly is select some length between pulleys, go to the curve for the pitch and start tightening; all instrument men to be furnished a pitch-pipe.

I haven't investigated this thoroughly but perhaps in an instrument with as many pulleys and string lengths as a Model R, it would be possible to determine a sequence of string plucking plus tension and come up with some song such as "Sixteen Tons." On a Model S there aren't many pulleys so here you might develop a solemn "Amen." Everyone knows what that sounds like—that's when you get up and leave church.

Panhandle Pete

Chatillon's compression springs with calibrated shims—an original Chatillon development—perform so accurately, they are specified in the precision instruments of leading manufacturers: e.g.: General Electric (ordnance equipment), Bendix (pressure transmitters), Chandler-Evans (aircraft carburetors). Shims brazed on the end coils of this spring maintain constant number of active coils during compression, thereby insuring constant rate. Straight line relationship between load and deflection is considerably improved. This great increase in accuracy, costs no more! Chatillon compression springs are available in Iso-Elastic* (Chatillon's own temperature-compensated alloy) or other spring alloys. Chatillon also manufactures Spiral, Torsion and Form Springs in Iso-Elastic and conventional alloys.

Have Chatillon's Spring Division show you how easily you may improve the accuracy of your instruments. Write for engineering bulletins.

*U.S.A. Pat. No. 2174171

JOHN CHATILLON & SONS
85 Cliff Street, New York, N. Y.
Manufacturer of Precision Springs and Measuring Apparatus Since 1835

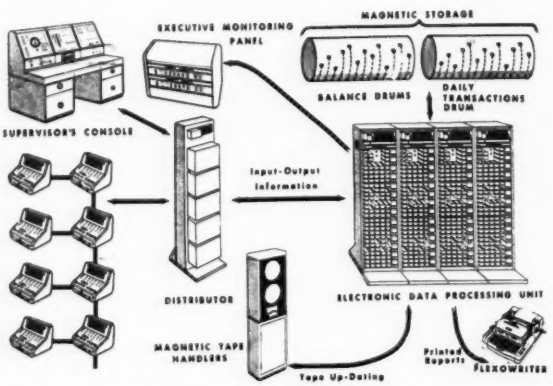
For more information circle **20** on inquiry card.

INSTRUMENTS and AUTOMATION News

Principles & Applications 1262 to 1276
Stock Report 1276
New Plants & Mergers ....1279 to 1280
People in the News .....1283 to 1284

Magnetronic Savings Account System

STAMFORD, CONN.—Teleregister Corp. soon will install the first completely automatic electronic savings bank system, in The Howard Savings Institution of Newark, N. J.



The electronic data processing system employs magnetic storage (drums and tapes) to control accounts, print pass books, display uncleared check conditions, and "lock up" in the event of an overdraft. The principal advantage of this system is that the teller can have access to central inventory showing the status of any account, at any time, instantaneously, on demand. It is estimated that this will result in a 30% reduction in the teller's time required to perform a transaction.

The network is completely integrated so that tellers at any of the 5 branch banks and at the main office of The Howard Savings Institution can take deposits or make withdrawals and immediately record this information on the central storage equipment in the main office of the bank.

As this system is leased by the bank and maintained by The Teleregister Corporation, the bank's operating cost is frozen at the rental figure. The Howard System is capable of handling up to 4,500 transactions per hour, and bank tellers are provided with instantaneous visual and printed reference on as many as 250,000 regular savings accounts.

Federal Airways Plan, 1957-1961

WASHINGTON, D. C.—The Civil Aeronautics Administration, responsible for all air traffic in U. S., has published a comprehensive booklet titled "Federal Airway Plan," Fiscal Years 1957-1961 (available from U. S. Dept. of Commerce, Washington 25, D. C., price $1.00). On 82 mimeographed pages, richly supported by maps, graphs, tables and statistics, the report foresees the needs of air traffic in the next five years with a forecast of 55 million passengers in 1960 and 70 million in 1965.

Plans are presented for all major and associated components of airways systems: Radar, VOR, DME, Airport Traffic Control, Air Route Traffic Control, ILS, Approach Lighting, LF/MF Radio Ranges, INSACS, Communications, ASDE, ATCOE, DF, PAR, NDB, Beacons, etc.

Office Automation Conference Co-Sponsored by Fordham University

NEW YORK, N. Y.—Gordon L. Mattson, Office Automation Consultant, will manage the Office Automation Conference to be co-sponsored by Fordham University School of Business during the Third International Automation Exposition in New York, November 26-30, 1956. The announcement is made jointly by the University and Richard Rimbach Associates, Inc., management for the Automation Exposition to be held at the new Trade Show Building, 500 Eighth Avenue.

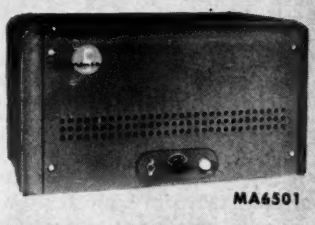
Last November Mr. Mattson served the University of Chicago in a similar capacity during the Second International Automation Exposition held in Chicago's Navy Pier. This conference brought together top executives or their representatives from the United States and a number of foreign countries.

Objective of the Office Automation Conference is to provide top management with information to guide them in making use of automation in data processing and the many other kinds of office work where the revolutionary techniques are applicable. Technical details are subordinated to the broad picture, with emphasis on integrating factors. Complete details concerning registration and schedule of the eight sessions will be forthcoming shortly, and will be mailed to interested persons upon request from Richard Rimbach Associates, Inc., Room 359, 525 Lexington Avenue, New York 17, New York.

L&N Opens New Plant

NORTH WALES, PA.—This industrial community 25 miles out of Philadelphia on the Reading Railroad's suburban line soon will be identified with "the world's most modern instrument plant" and the 57-year old name of Leeds & Northrup Co. L&N's highly modern 11-million dollar plant adds a special flavor to the community; it has over 6 acres under one roof, sits in a 129-acre tract and will employ about 1300 people.

Open house was held May 11 through 15, and president



MA6501

MA6501 — tubeless 0.01% regulated DC supply; 6 and 2 volt outputs.

•

ELECTROSTATIC GENERATOR for lab or industrial high-voltage applications.

•

MA1000S — tubeless, dependable 1000VA regulator, ideal for unattended installations.

MA1000S

NEW PRODUCTS . . . BROADER ENGINEERING HORIZONS FROM SORENSEN

MR3215 5-32VDC AT 0-15 AMPS
new, tubeless, magnetic amplifier

WIDE RANGE REGULATED DC POWER SUPPLY

for versatile, trouble-free performance in countless design & test applications

Different outside . . . and *inside!* The latest design in magnetic amplifier regulation. A silicon diode is used as reference element and a transistor amplifier provides the control current for the magnetic amplifier. Wide range, continuously adjustable voltage at high current. Regulation ±0.5% against line or load, ripple 1% RMS. Versatile, dependable, rugged, economical.

Write today for detailed specifications, performance data, and quotations.

Sorensen

SORENSEN & COMPANY, 375 FAIRFIELD AVENUE, STAMFORD, CONN.

For more information circle **21** on inquiry card.

STANDARDS

ENGINEERS

for Primary Standards and Instrumentation

At Hughes we are conducting fundamental research and development and production engineering in the fields of radar systems, guided missiles, digital and analog computers, microwave tubes, semiconductor products and other activities requiring use of many types of test equipment.

Those with extensive experience in the calibration and maintenance of precision electronic and electromechanical test equipment—with emphasis on measurement of electrical quantities to very close tolerances—will find satisfying outlets for their abilities in this work at Hughes.

HUGHES

Scientific Staff Relations

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

DEW POINT READING ★ -67°F. with THE HANKISON Dehydrafilter

★ ALWAYS assures moisture-free Compressed Air and Gas for DEAD-END OR LOW FLOW CONTROL APPLICATIONS

★ Eliminates expensive tracing of compressed air lines

SATURATION INDICATOR

DESICCANT CARTRIDGE IN BRASS CASE

PURGE COCK

Model CM-1 (illustrated) contains a replaceable desiccant cartridge for adsorbing moisture vapors. Rated Capacity: 1 SCFM @ 100 psig and 70° F.

Models for service up to 25 SCFM @ 6000 psig.

Write for Bulletin C-554

HANKISON CORPORATION

P.O. Box 8044B, Pittsburgh 16, Pa.

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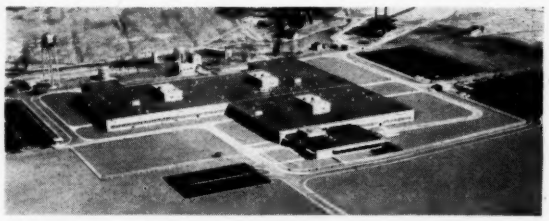
NEWS—CONTINUED



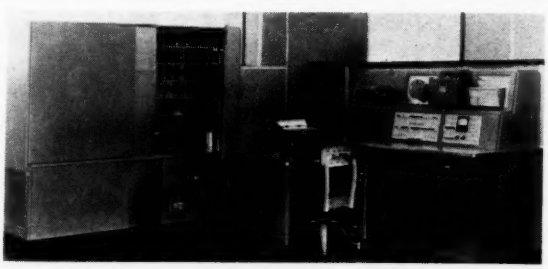
I. Melville Stein officiated. He cut "a magic tape," using the opportunity to commemorate Benjamin Franklin's 250th anniversary. An actor in Franklin attire rubbed a glass tube to create static electricity. A spark device, a spherical electricity-receiving terminal, an L&N amplifier and a Speedomax Recorder were the other accessories used to "cut" the tape by electricity.

The North Wales plant has taken over production of all recorders, controllers and industrial control equipment. Headquarters of the company stay at the Germantown plant in Philadelphia, where scientific instruments have been built for many years.

A remarkable innovation in the new plant is a signal-handling network with voice paging, signal paging, plant-protection, and fire signals, executive communications, and music. The "Safetemp" system (standing for Security, Auditorium, Fire, Emerging, Time, Executive, Music, and Paging) allows direct paging from the 16-mile-remote Philadelphia plant.

Univac AF/CRC Magnetic Computer

NEW YORK, N. Y.—Two revolutionary developments in high-speed, general-purpose electronic computer construction were revealed recently in a demonstration of the new, compact, Remington Rand Univac AF/CRC



Magnetic Computer, designed and built for the Air Force Cambridge Research Center at Lawrence G. Hanscom Field, Bedford, Mass.

The Univac Magnetic employs tiny pulse-amplifying Ferractors in its internal magnetic-core circuitry and a five-by-three inch magnetic drum (16,500 rpm) to accomplish a remarkable over-all reduction in size (apparent from the picture) without sacrifice of speed or capacity. The Ferractor is so small that forty would just about fill a jumbo peanut shell. The drum is sealed in a casing about a cubic foot in size and filled with helium to lessen frictional resistance. In addition, helium has a much higher heat transfer coefficient than air allowing the drum to run considerably cooler.

Univac Magnetic uses a parallel bit serial digit code at a 660 kilocycle per second bit rate, which allows the

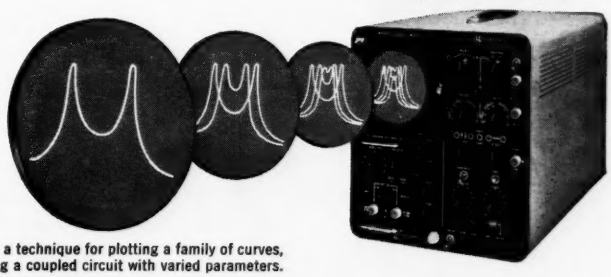
HUGHES MEMOTRON®

. . . a new concept in retaining transients

- Provides an instant and convenient permanent display of transients
- Displays traces at high brilliance indefinitely, until intentionally erased
- Permits display of successive writings
- Eliminates waste of time and film by eliminating need for taking superfluous photographs
- Can be used as a curve plotter at both high and low writing speeds.

MEMOTRON *is exclusive with Hughes. It is the only cathode ray tube available which makes it possible to combine, in a single piece of equipment, the permanent writing characteristics of a pen recorder together with the high-frequency response of a cathode ray oscillograph.* MEMOTRON *is already incorporated into equipments serving important laboratory functions in many of the country's leading electronics research and manufacturing centers. Descriptive Product literature is available upon request.*

An application of the MEMOTRON is a commercial oscilloscope manufactured by Advanced Electronics Corporation, Los Angeles. MEMOTRON has an over-all length of 18½ inches, and a neck diameter of 2¼ inches. It can replace most conventional 5-inch tubes without revision of space requirements in the equipment.



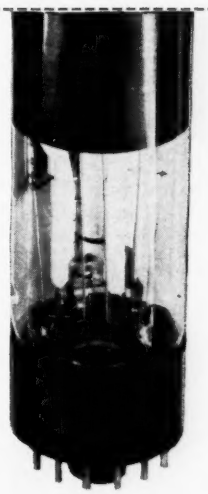
Illustrated: a technique for plotting a family of curves, representing a coupled circuit with varied parameters.

Hughes Products engineers are available for consultation on special MEMOTRON *applications. For literature write to address below.*

HUGHES PRODUCTS

A DIVISION OF THE HUGHES AIRCRAFT COMPANY

ELECTRON TUBES
HUGHES PRODUCTS
Los Angeles 45, California



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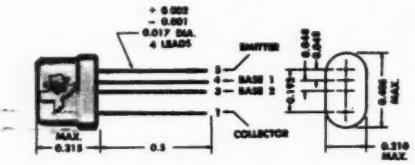
For more information circle **23** on inquiry card.

addition of two 10-digit numbers in 90 microseconds, over 11,000 additions per second, and multiplication in from 0.3 to 1.7 milliseconds, over 3000 multiplications per second.

Its use of paper tape makes the new computer compatible with all common-language processing, instrumentation, or data-presentation systems.

Transistors for VHF

DALLAS, TEXAS—A radically new transistor manufacturing technique announced by Texas Instruments Inc. is said to "break through the radio-frequency barrier." The new "grown-diffused" technique works with both



germanium and silicon and the resulting commercially available kernel-sized production transistors amplify electrical signals at usable power levels to over 100 megacycles, and will oscillate to over 250 megacycles per second.

Silicon transistors now in production by this new process have gains of 15 db at 12.5 megacycles and 14 db at 30 megacycles with useful power levels up to 150°C. A "grown-diffused" germanium transistor with a power gain of 10 db minimum at 100 megacycles and with a collector dissipation of 25 milliwatts at 75°C is also in production. Frequency cutoff is 200 megacycles. These are ultra-conservative figures that are "guaranteed minimums" for production transistors.

Magnetic Amplifiers, Transistors

WASHINGTON, D. C.—Among the new catalogs of Technical Reports (published by the Office of Technical Services, U. S. Dept. of Commerce, Washington, 25, D. C., price 10 cents each) are two of special interest to our readers: CTR-310 *The Transistor*, and CTR-244 *Magnetic Amplifiers*.

CTR-310 lists 35 reports from 1949 through 1955, and includes such fundamental works as *The Transistor*, Bell Telephone Labs., 1951 (PB111054, 800 p., price $20); reports from scientific institutions, primarily Yale University, Princeton University, MIT, Battelle Memorial Institute, etc.; military studies of USAF, the Navy, the Signal Corps, etc.; and publications from private industry, including Beckman Instruments, Zenith Radio, IBM, etc.

CTR-244 lists 34 developments from 1940 through 1955 which include German documents captured in World War II, and the exhaustive report *Magnetic Amplifiers* from Carnegie Tech, Pittsburgh, in 6 parts (PB114429 through PB114434, available singly on microfilm or as photocopy from the Library of Congress at prices ranging from $1.50 to $11.50) as well as military research reports, and studies emanating from U.S. and foreign institutions of higher learning.

Data Lab on Wheels

LOS ANGELES, CALIF.—Benson-Lehner Corp. recently delivered a mobile data-reduction, data-handling laboratory to the Air Research and Development Com-

mand's Wright Air Development Center. It contains, among its data-reduction facilities, a Benson-Lehner OSCAR (oscillograph anlyzer and recorder) Model E, two OSCAR Model J's, an ELECTROPLOTTER, a BOSCAR (ballistic film analyzer and recorder), two Flexowriters, three tape punches, and a complete film processing lab.

Education News of the Month

▸ At recent IRE Conference in Dayton, Ohio, Dr. Cledo Brunetti, director of engineering, research and development for the Mechanical Division of General Mills, Inc., has revealed a possible source for qualified technical personnel. Analyzing the operation of the weapons system concept as it is now operating, he pointed out that it allocates the major military research and development contracts to 20 or 30 big companies. But about 200 or 300 middle sized companies, to a large extent, are being left out of the picture. Their combined research and development force may be equal or even superior to the staff of the large firms. He suggested using this reservoir by assigning these smaller companies specific responsibilities for specialized sub-systems—thus freeing technical personnel of the large contractors for other tasks.

▸ The new catalog on U. S. Government Awards under the Fulbright and Smith-Mundt Acts (for advanced research and University lecturing abroad in 1957-58) includes many openings in the field of engineering such as Nuclear Physics, Servo-Mechanics, Fluid Mechanics, Atomic Reactors, etc. Closing date for applications is October 1, 1956. Correspondence is to be directed to the Executive Secretary, Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Ave., Washington 25, D. C.

▸ A BS-degree in fire protection now is offered by a four-year curriculum at University of Maryland. The University has been giving short courses for volunteer firemen since 1930, with a present enrollment of 1955 students.

▸ Truesdail Labs of Los Angeles and Honolulu have created a $1000 annual scholarship at the University of Redlands (with opportunity for summer employment at the lab) for a chemistry major "to contribute toward the relief of the current shortage of trained scientific personnel."

PANELS · TIMERS · TACHOMETERS
by Standard Electric

flexlab PANELS
Distribution Switchboards
Control Panels, Test Benches and Units

Custom Designed and Custom Built for a long and impressive list of users in Industry, Research, Government, and in Vocational and Technical Schools and Universities. **Send for Bulletin 187.**

flexlab RECEPTACLES AND PLUGS and binding posts, for quick, frequent, flexible, plug-in connections for power distribution and circuitry on test or production equipment. **Send for Bulletin 238.**

Precision TIMERS

For extreme accuracy and continuous performance. Rugged, for heavy duty service; flexible in application; to measure and indicate elapsed time intervals. Synchronous motor drive. Electric clutch controlled by manual switch, automatic switch or output of electronic tubes. Manual or electric zero reset. **Send for Bulletin 198.**

Model	Scale Divisions	Totalizes	Accuracy
S-100	1/5 sec.	6000 sec.	±.1 sec.
S-60	1/5 sec.	60 min.	±.1 sec.
SM-60	1/100 min.	60 min.	±.002 min.
S-10	1/10 sec.	1000 sec.	±.02 sec.
S-6	1/1000 min.	10 min.	±.0002 min.
S-1	1/100 sec.	60 sec.	±.01 sec.
MST	1/1000 sec.	.360 sec.	±.001 sec.
MST-500	1/1000 sec.	30 sec.	±.002 sec.

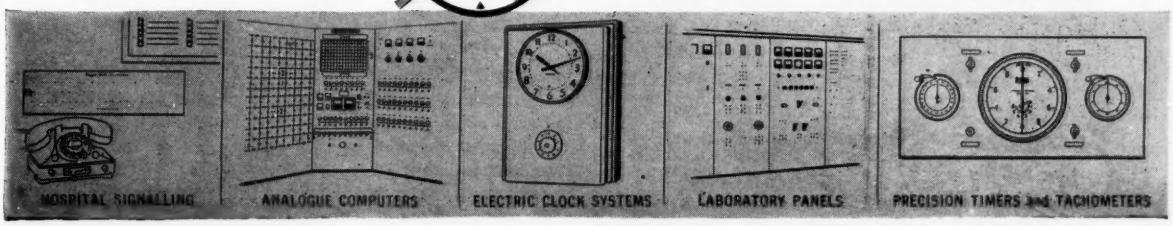
Chrono and Electronic TACHOMETERS

These NEW and IMPROVED TACHOMETERS are designed to give you these outstanding benefits: Extreme Precision — Reliability — Readability — Self-Checking — Package-type, plug-in construction to simplify servicing. **Write for Bulletins 218 and 240.**

Write for Bulletins listed above. For information on specific problems, address inquiries to our Engineering Department.

THE Standard ELECTRIC TIME COMPANY

93 Logan Street • Springfield 2, Massachusetts



For more information circle **24** on inquiry card.

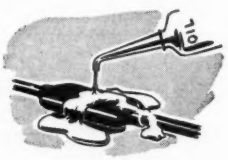
Partners in Production

Joy Electrical Connectors and Automatic Controls

What happens to Automation . . . when electrical connectors fail?

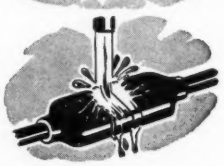
No automatic control system yet devised will keep machines running when an electrical plug or receptacle in their power feeder line or power control circuit *poops out.* That's why JOY's one-piece molded Neoprene connectors deserve your careful consideration. Factory wired and permanently molded to cord or cable, they provide many extra advantages that add up to a long life of dependable service under the most adverse operating conditions. (A few are listed below.) Available in a wide variety of designs with 1 through 16 contacts for 150 to 600 volt applications. **Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.** In Canada: *Joy Manufacturing Co. (Canada) Limited, Galt, Ontario.*

Oil-Sealed . . .
One-piece molded cable connector assembly protects conductors from oil and other external impurities. Face rings protect contacts from similar contamination, when connectors are engaged.



Distortion-Proof . . .
Factory molded as trim one-piece synthetic rubber jacketed units, JOY connectors cannot crack, will not shatter and are practically impossible to knock out of shape.

Moisture-Tight
JOY electrical connectors are absolutely moisture-tight from wiring juncture to face . . . and when connected even their contacts are protectively encased in a resilient housing.



CD 355.2

JOY
SOURCE OF INDUSTRY'S FAVORITE ELECTRICAL CONNECTORS SINCE '28

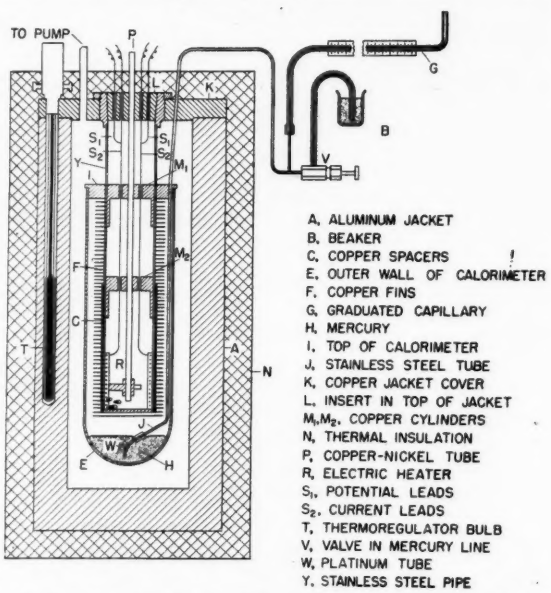
For more information circle **25** on inquiry card.

Digital and Analog Computers

DENVER, COLO.—Denver Research Institute, in cooperation with the National Simulation Council, will hold its Third Annual Symposium on Digital and Analog Computers, August 30 and 31, 1956, Hotel Albany, Denver, Colo. Among the speakers will be John H. McLeod, Jr. of Convair, Chairman of the Steering Committee of the National Simulation Council and editor of the Simulation Council Newsletter, Dr. John W. Carr of the University of Michigan, and Dr. Ascher Opler of Dow Chemical. Dr. Carr will continue after the Labor Day recess with a special advanced course in computer techniques (Sept. 4 through 7); Mr. McLeod will advise with interested persons on organizing a Denver area Simulation Council. Information is obtainable from Wm. B. Kennedy, The Denver Research Institute, University of Denver, Denver 10, Colo.

Calorimeter for Polymers

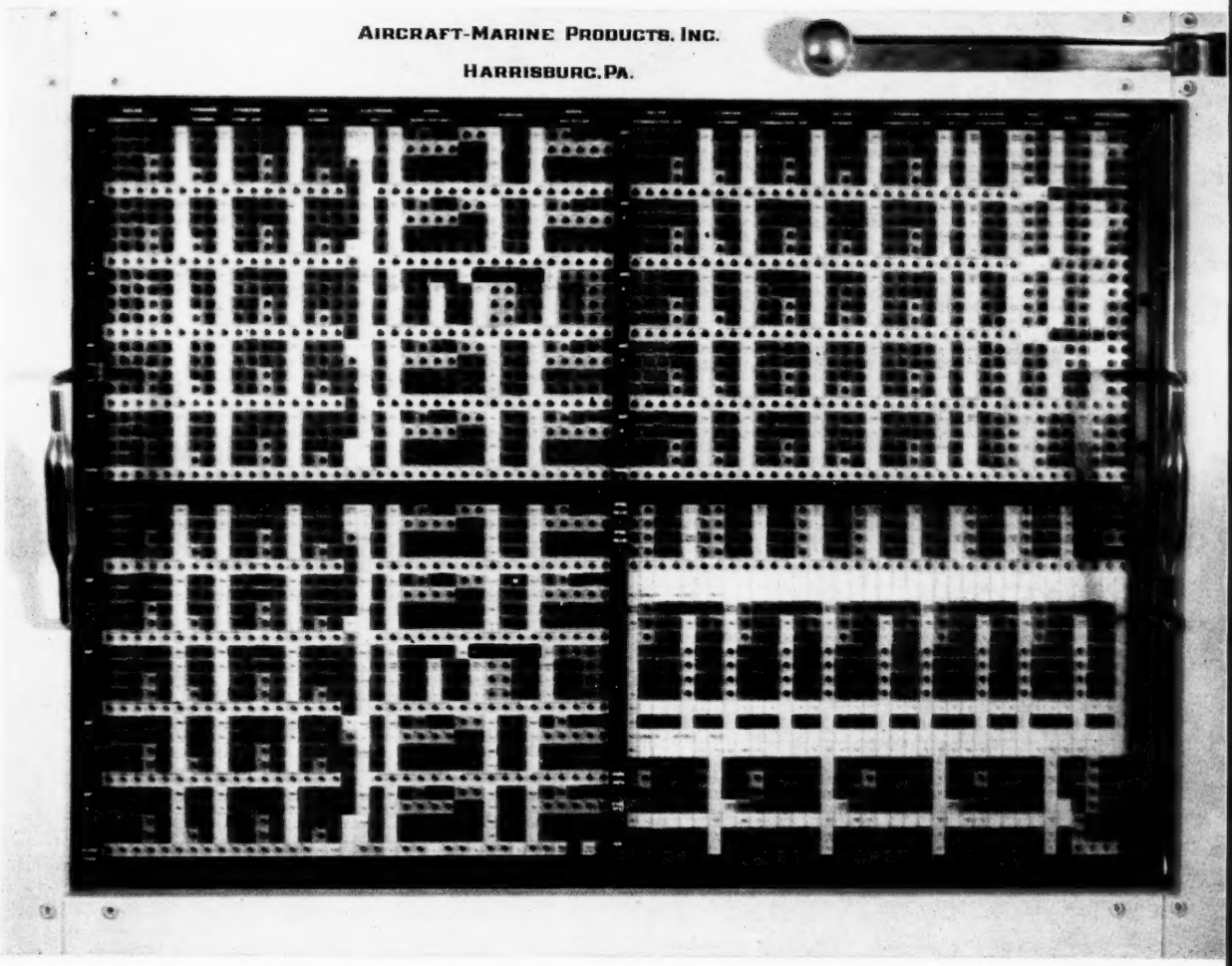
WASHINGTON, D. C.—A calorimeter that measures very small quantities of heat, precisely, at room temperature has been designed by the National Bureau of Standards. It is particularly suited to measurements of heat of reaction, heat of solution, and heat of mixing of polymeric and other substances, data which are of interest to the rubber industry. Similar in principle to previous Bunsen-type calorimeters, it has been modified to permit the use of diphenyl ether instead of water as the calorimetric substance.



Digimatic

LOS ANGELES, CALIF.—"Digimatic" is a new "numerical control" device for operating complex machine tools by means of digital "instructions" that are automatically computed and recorded on magnetic tape. A development of Electronic Control Systems, Inc., an affiliate of Stromberg-Carlson and a subsidiary of General Dynamics Corp., "Digimatic" consists of two principa

For more information circle **26** on inquiry card. →



THE NEW AMP CELLULAR,

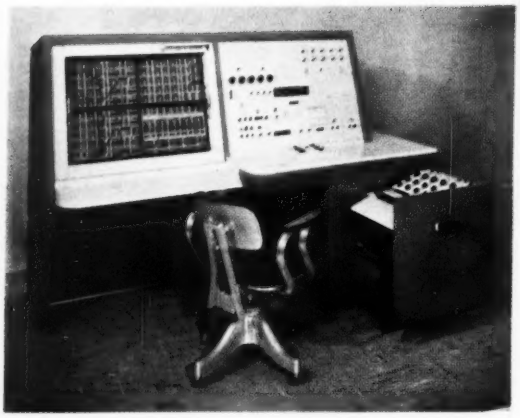
SHIELDED PATCHCORD

PROGRAMMING SYSTEM

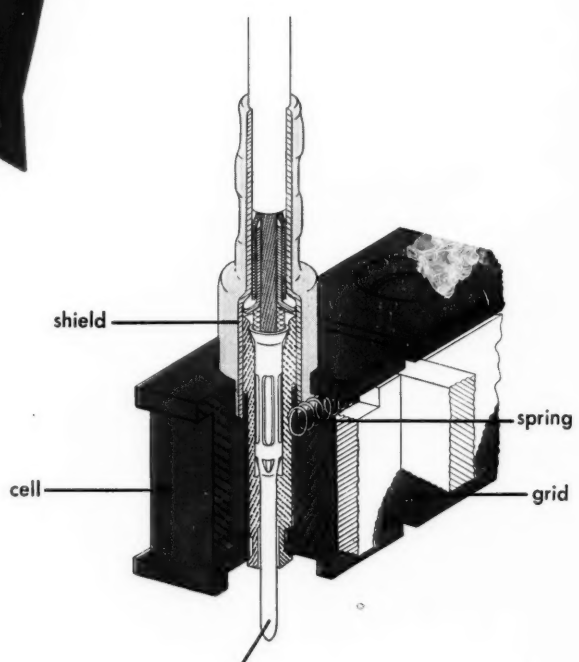
A-MP's revolutionary Cellular, Shielded Patchcord Programming System

is constructed of molded nylon blocks alternated with interlocking metal strips. The hole in each block accommodates: standard patchcords, coaxial (shielded) patchcords, or special "L" type shielded patchcords.

This cellular system of construction prevents current leakage from one circuit to another, while providing all the advantages of a metal patchboard. Its insulated surface and flexibility of arrangement, spacing and color coding offer exceptional versatility on computers, test equipment, business machines, and all types of automated industrial and military equipment.



The illustration shows how Berkeley Division of Beckman Instruments, Inc. is using A-MP's new Patchcord System in its new EASE* 1200 Analog Computer.



A-MP

Aircraft-Marine Products, Inc.

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Aircraft-Marine Products (G.B.) Ltd., London, England
Societe A-MP de France, Courbevoie, Seine, France

*Trade mark, Berkeley Division of Beckman Instruments, Inc.

units—a planning desk, the main part of which is a high-speed decimal computer and tape recorder, and a machine control unit which governs the operation of a machine tool by the "instructions" on the magnetic tape.

In a recent demonstration, by pressing a button, a typical precision cam was machined completely from a metal blank, with the magnetic tape controlling all the operations of a vertical milling machine.

A.F.R.A.

PITTSBURGH, PA.—In our May issue we reported the founding of automation societies in Italy, Belgium, and Norway. This month news of the formation of such an association comes from France.

L' Association Francaise de Régulation et d' Automatisme (A.F.R.A.) has been organized, requiring membership (for regular members) in one of the six societies —for civil, electrical, radioelectrical, and mechanical engineers, industrial chemists, or the group for the advancement of industrial mechanics. Main aim is to consolidate and coordinate the efforts of these various groups, and to maintain good relations with similar associations in France and abroad.

Honorary president is M. Pierre Nicolau, president is M. Marcel Véron, and treasurer is M. Jean Vivié, editor-in-chief of the magazine "Mesures."

Stratospheric TV

PHILADELPHIA, PA.—Philco Corp. has developed an airborne TV system which will provide ground control points with an active picture of troop movements or terrain. It now is possible to transmit a TV picture from the stratosphere, beyond reach of antiaircraft gun fire.

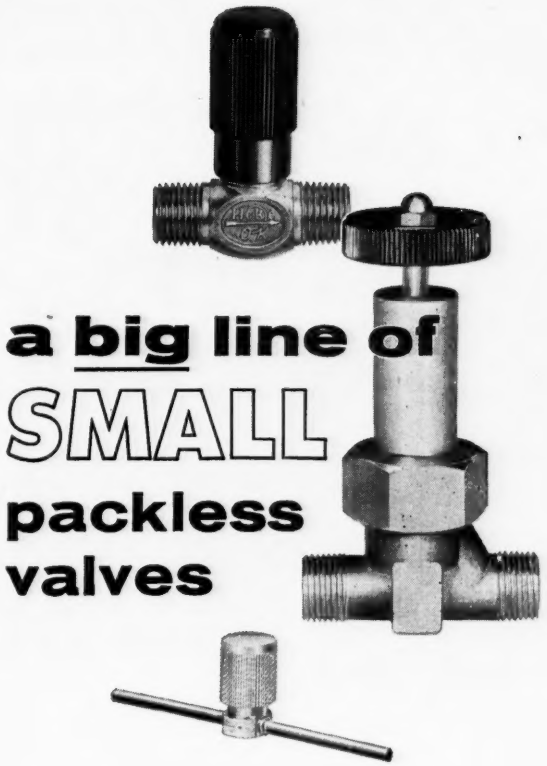
The new airborne reconnaissance system is a complete, self-contained, broadcasting station. It is so compact that it may be carried in single-seat aircraft. To cover a wide area, two unmanned, studio-quality TV cameras are used in the plane. A clear, sharp picture from aircraft traveling at supersonic speeds can be transmitted to the ground control point where it is picked up by a receiver. There, the picture may be instantaneously photographed on 35mm film which can be processed in less than a minute. Immediately, the picture may be projected on theater-size screens at the control point, or relayed to other locations.

Flight Control/Bomb System

WASHINGTON, D. C.—The Security Review Branch, Dept. of Defense, recently revealed an electronic system permitting this nation's newest strategic bombers to find and destroy unseen enemy targets with unprecedented accuracy. A specially-developed Sperry A-14 automatic flight control system and an MA-6A electronic bombing system are installed in the new Boeing eight-jet B-52 Stratofortress, the intercontinental bomber.

Designed by Sperry Gyroscope Div. to Boeing and Air Force specifications, the A-14 flight system provides precision control and aids in instrument landing.

The advanced MA-6A bombing system, utilizing target data obtained either optically or by radar, automatically "feeds" steering information to the automatic flight control system as the bombardier makes the necessary com-



a big line of SMALL packless valves

Packless valves are designed for tough applications, like critical high vacuums, corrosive or dangerous fluids and high temperatures. Our experience with these problems has helped us to design a packless valve line broad enough to suit many of these applications. As evidence may we present:

The 431 Series – a greatly improved version of the Hoke brass bellows needle valve offering extended, leak-tight service life . . . suitable for sampling systems and analysis equipment—bronze bellows, stainless steel (blunt or vee) spindle in ⅛" and ¼" pipe sizes.

The 480 Series – Globe or angle valves in brass or monel with phosphor bronze or monel bellows.

The 440 Series – for supercritical applications An all stainless bellows valve with Teflon seat—⅛" to ½" pipe sizes. (Both 480 and 440 series have replaceable bellows assemblies.)

The 411 Series – All metal monel diaphragm valves with low internal volume and excellent service life.

For those of you who have special problems, modifications of these valves are available for high temperatures and pressures. You'll find us most receptive to your inquiries.

WE'VE JUST COMPLETED A NEW PACKLESS VALVE BULLETIN THAT WE'D LIKE TO SEND TO YOU. WRITE TO

HOKE

HOKE INCORPORATED

Fluid Control Specialists

231 S. DEAN STREET, ENGLEWOOD, NEW JERSEY

For more information circle **27** on inquiry card.

← For more information circle **26** on inquiry card.

PIONEERING is our business

Volume cleaning in seconds with Bendix ULTRASONICS

Typical parts and assemblies cleaned by Bendix Ultrasonics.
(*Parts for these assemblies are cleaned prior to assembly.)

Clean more parts and assemblies! Accommodate standard baskets and racks! Reduce costs!

Rectangular cleaners make Bendix Ultrasonic Cleaning even more efficient, even more useful than before. Models are now available in a choice of sizes: 18″ x 25″ x 18″ . . . 9″ x 14″ x 13″ . . . 6″ x 18″ x 13″ . . . or 7″ x 9″ x 11″.

The large, rectangular units offer *increased cleaning capacity. Cleaning is exceptionally thorough* . . . because the entire bottom of the cleaner develops cleaning cavitation. The rectangular cleaners *accommodate baskets and racks already used in production cleaning.*

Besides those advantages, Bendix Ultrasonics clean faster and 99.5 percent to 100 percent effectively . . . eliminate costly, hazardous solvents . . . clean even most delicate parts safely . . . greatly reduce cleaning costs. Get full details. Write PIONEER-CENTRAL DIVISION, BENDIX AVIATION CORPORATION, DAVENPORT, IOWA.

West Coast Office: 117 E. Providencia, Burbank, Calif.
Southwest Distributor:
Southwestern Eng. & Equip. Co., 3906 Lemmon Avenue, Dallas, Texas
Export Sales and Service:
Bendix International Division, 205 E. 42nd Street, New York 17, New York
Canadian Distributor:
Williams & Wilson, Ltd., 11 Front Street, East, Toronto, Canada

Pioneer-Central DIVISION — Bendix AVIATION CORPORATION

For more information circle **28** on inquiry card.

NEWS —CONT.

mands. This, in turn, controls aircraft action required to maintain a desired course and altitude, to guide the super bomber to a predetermined, precise pin-point in space at which a bomb must be released to strike the target.

News Bits

REMINGTON RAND'S new contribution to office automation is an adaptation of a Kardex file for storing non-variable or repetitive information for common-language data-processing operations. Information thus stored can be reproduced automatically into the conventional working tape with the variable data (such as quantities to be ordered) added manually.

MINE SAFETY APPLIANCES CO. has installed its new "Telechrane" FM carrier communications system at the Sheffield Steel Div. of Armco Steel Corp. in Kansas City. Transmitting signals over existing electrical circuits, the system is free of outside interference and crane operators can hear clearly above the noise of nearby operations.

GENERAL ELECTRIC CO. has built a giant analog computer for the Air Research and Development Command that could save up to two years in the costly development of advanced-design jet engines. It will enable engineers to "fly" jet engines and to forecast performance before they are built.

GE Computer

Ocean-going Lab

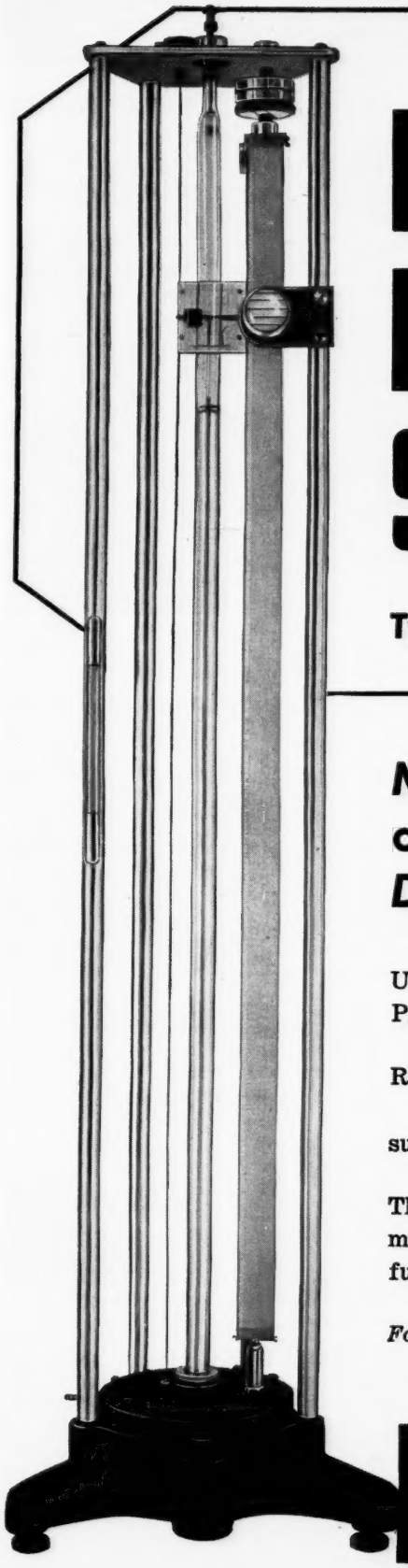
REED RESEARCH INC. has equipped the 64-foot vessel *Marigold* as an ocean-going laboratory to tackle some of the unsolved problems which exist in the marine field, especially in navigation.

WESTINGHOUSE ELECTRIC CORP. will design (for Yankee Atomic Electric Co.) a pressurized light-water-cooled-and-moderated reactor for producing 134,000 kw of electricity. This is the first contract under the AEC's Power Demonstration Reactor Program.

BERKELEY DIVISION has again given its annual five-day factory training course in Richmond, Calif. It included electronic engineers from aircraft firms (Boeing, Convair, Douglas, Bell) and other companies (Ford Motor Co., Bendix Aviation, Minneapolis-Honeywell, etc.).

THE NAVAL RESEARCH LAB. has developed a sound spectrograph which presents an instantaneous plot of the energy of an audio signal on a new type of chemically treated electrosensitive paper.

FISCHER & PORTER'S Automatic Data Logger will record Tide Table predictions, replacing manual logging



MERCURIAL-PRECISION STANDARD

Type FA-187

Measures *Absolute* or *Differential Pressure*

Used interchangeably as a Barometer or Differential Pressure Manometer.

Range: 0 to 800 mm of Hg.
0 to 31.5 in Hg. or in any other desired pressure unit of equivalent range.

The magnetic vernier reads to 0.01 mm or 0.005 in. of mercury with an accuracy of 1 part in 5000 over the full range.

For additional information, write for Publication Number TP-32-A.

WALLACE & TIERNAN
INCORPORATED
PRECISION INSTRUMENTS AND ELECTRICAL MECHANISMS
25 MAIN ST. BELLEVILLE 9, N. J.
In Canada: Wallace & Tiernan, Ltd., Toronto

A-103

For more information circle **29** on inquiry card.

Precise

TEMPERATURE MEASUREMENTS

. . . with the Rubicon

MUELLER BRIDGE

A highly accurate and specialized form of the Wheatstone bridge designed expressly for precise resistance thermometry with three- or four-lead thermometers and for the measurement of other similar resistors within its range.

- Wide range: 0 to 141.1110 ohms in increments of 0.0001 ohm
- Unity ratio with provision for convenient checking and precise adjustment of ratio arms
- Built-in mercury commutator for lead resistance compensation
- Sub-panel switch construction
- Built-in plug and block assembly for conveniently checking ratio, bridge zero and thermometer resistance with no disturbance of external bridge connections

Described in Bulletin 100

. . . with the Rubicon

PORTABLE PRECISION POTENTIOMETER

A two-dial instrument of exceptional accuracy and sensitivity.

- High-sensitivity, sturdy, built-in Pointerlite galvanometer —permits balancing to within 2 microvolts in low resistance circuits
- Completely self-contained assembly—no external accessories except the thermocouple circuit
- Two ranges —0 to 16.1 and 0 to 161 millivolts—readable to within 2 and 20 microvolts respectively
- Sturdy, compact construction for long dependable service

Described in Bulletin 270

RUBICON COMPANY

Electrical Instrument Makers

3755 Ridge Avenue Philadelphia 32, Pa.

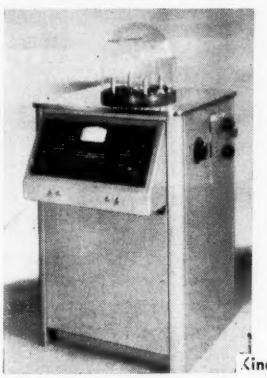
For more information circle **30** on inquiry card.

NEWS —CONTINUED

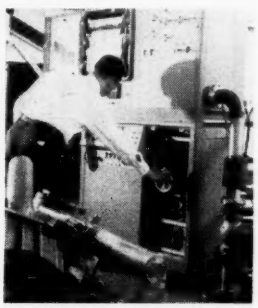
on tables from the Tide Predicting Machine in operation since 1910.

BELL TELEPHONE LABS. report successful fabrication of thermistor materials having large *positive* temperature coefficients.

KINETICS CORP. announces a new production facility for vacuum brazing, especially useful for waveguide and microwave assemblies. Temperatures to 2100°F can be maintained at high vacuum of 10^{-5}mm.



Kinetics Vacuum Brazer



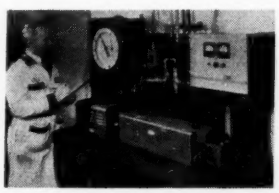
CEC Mass Spectrometer

CONSOLIDATED ELECTRODYNAMICS CORP. has custom-built a mass spectrometer which was installed on the vacuum melting furnace platform at Carboloy Dept. of GE. The unit helps determine and control progress of the high-vacuum process by analyzing gases produced in the furnace while special alloys are made.

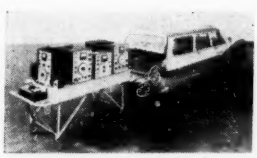
NBS has published a report on transcendental-function analogue computation with magnetic cores.

U. S. AIR FORCE and Lockheed-Georgia have announced that an immediate start would be made on a giant nuclear aircraft testing and research facility near Dawsonville, Ga., with 500 scientists, engineers and technicians.

BECKMAN spectrophotometer is used on the production line of AP Parts Corp. to check every 500-gallon batch of Miracle Power, a colloidal synethetic graphited lubricant. If sample does not pass test, entire 500-gallon batch is rejected.



Beckman Spectrophotometer



Brush Lab-on-Wheels

BRUSH ELECTRONICS CO. again will put its "laboratory on wheels" on the road to give field demonstrations of sound, vibration and strain measurements.

HANKISON CORP. has announced shipment of a stainless steel "Condensifilter" to the Electric Boat Division of General Dynamics Corp. for installation on the "SEAWOLF," the atomic submarine.

AMERICAN SILVER CO. has succeeded in the production of copper strip in thickness of 0.00025"—1/12 the

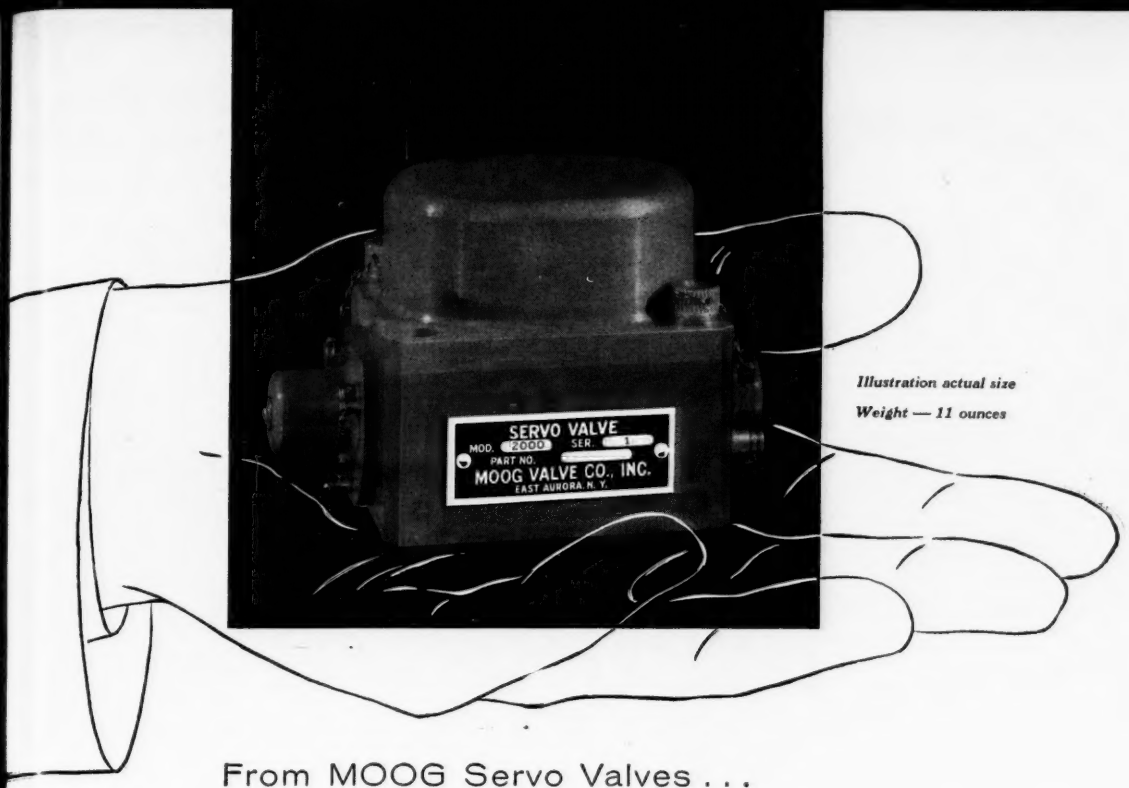


Illustration actual size

Weight — 11 ounces

From MOOG Servo Valves . . .

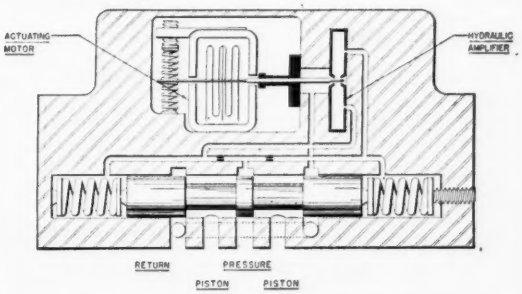
High Accuracy and Response

One of the outstanding characteristics of Moog Servo Valves is their exceptionally high dynamic performance. Moog units are characterized by equivalent time constants as low as one and one half milliseconds from input differential current to output flow.

Performance of this magnitude makes possible control systems of high accuracy and response. Typical applications for these valves are in servo systems of advanced aircraft and guided missile flight controls, radar scanner actuation, contour following machine tools, and automatic packaging equipment.

Conventionally, valve input is from a balanced push-pull DC amplifier and valve flow output is applied to a piston or hydraulic motor. An electric signal proportional to piston position or motor angular rotation is fed back to the amplifier to give a closed servo loop.

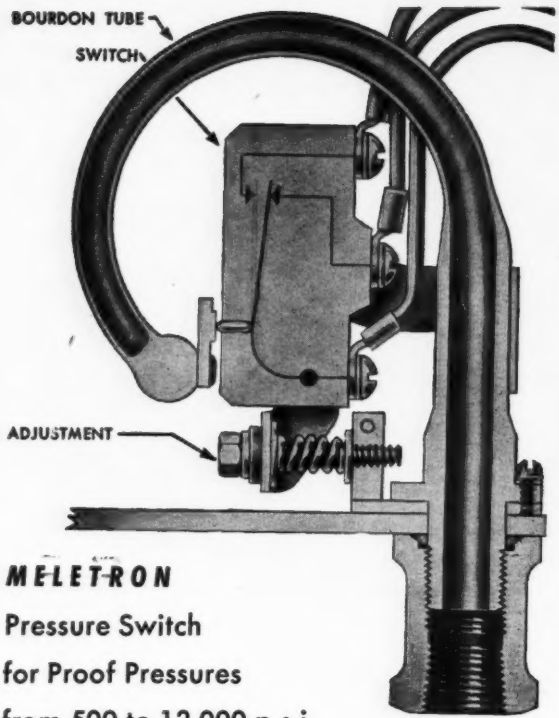
Production models are designed to operate in hydraulic systems of from 1000 to 3000 PSI pressure. Rated output flow from 0.1 to 50.0 GPM, for control currents between 2.0 and 40.0 milliamperes as specified, are available in production units.



For details write for Bulletin 2000-1

MOOG VALVE CO., INC. PRONER AIRPORT EAST AURORA, N. Y.

For more information circle **31** on inquiry card.



MELETRON
Pressure Switch
for Proof Pressures
from 500 to 12,000 p.s.i.

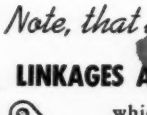
Competes on Price
Wins on Accuracy

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS



which, as they wear, cause settings to drift.

IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS

which require that the pressure switch be mounted absolutely vertical, which make it very critical to vibration.

To get complete operating characteristics and specifications ask for bulletins 302 to 382.

BARKSDALE VALVES

PRESSURE SWITCH DIVISION
5125 Alcoa Avenue, Los Angeles 58, California

For more information circle **32** on inquiry card.

NEWS—CONTINUED

thickness of a human hair—to be used in miniaturized transformers and components.

Financial News

DYNAMICS CORP. OF AMERICA recorded highest sales in its 32-year history in 1955. Consolidated sales of $41 million were up 15% from 1954.

FISCHER & PORTER announces shipments exceeding $11 million for the fiscal year ending April 30, 1956. New Latin American representatives have been appointed; S.A.V.E.R. Guinand for Venezuela and Tecnica Colombiana S.A. for Colombia.

SERVOMECHANISMS INC. announces first quarter net sales over $3 million, and backlog at all-time high.

Stock Report

The following prices and price ranges are supplied by Bache & Co., 36 Wall Street, New York 5, New York.

New York Stock Exchange:

Security	Price Range for 1956 Thru May 31 High	Low	As of May 31 Last
Aeroquip Corp.	15 3/8	11 7/8	14 1/8
American Chain & Cable	48	38 1/2	44 1/4
American Mach. & F.	32 1/8	24 1/8	28 1/2
American Mach. & M.	40 3/4	35 1/8	38 1/4 - 38 3/4 (1)
American Optical	40 3/4	35	35 3/8
Beckman Instruments	31 1/2	25 1/8	26 1/2
Bell & Howell	45 1/2	28 1/4	40 - 40 7/8 (1)
Bendix Aviation	63	49	51
Bulova Watch	23	20 1/2	20 3/4
Burroughs	41 1/2	28 1/2	39
Clevite	24 1/4	18 1/4	18 7/8
Dobeckmun	39 1/4	31 3/4	34 1/4
Gamewell	31 1/2	25 5/8	29
General Inst.	10 1/8	7 3/4	7 3/4
General Prec.	53 1/2	40	41 1/4
General Time	33 1/8	29 1/2	30 1/8 - 30 7/8 (1)
Hamilton Watch	25	19	22 5/8
International Business Mach.*	439	400	429 1/2
Minneapolis-Hon.	78 3/4	58	72
National Cash Reg.	50 5/8	34 1/8	45 7/8
Radio Corp.	50 3/8	41 1/8	43
Raytheon	19 1/2	14 5/8	15 3/8
Robertshaw-F.	28 3/8	23 7/8	24 1/8
Sangamo Electric	37 1/2	29 1/2	33
Sperry Rand	29 1/8	23 5/8	24 1/2
Square D	74 1/2	51 1/2	65 1/4
Starrett, L. S.	56 1/2	43 3/4	51
Sylvania Electric	55 7/8	42	49 5/8
Telautograph **	15 1/4	12 7/8	13
Texas Inst.	14	11 5/8	12
Underwood	44	32 7/8	33 7/8

(1) Bid - Asked price, no sale.
* Reflecting adjustment for 25% stock dividend.
** Adjusted for 2 for 1 split on May 4, 1956.

American Stock Exchange:

Security	Price Range for 1956 Thru May 31 High	Low	As of May 31 Last
Air Assoc.	13 1/2	9	11 3/8
American Meter	41	34 1/8	34 - 34 1/2 (1)
Benrus Watch	10 3/8	9 1/8	9 1/4
Breeze Corp.	9 1/8	6 5/8	7 1/8
Consolidated Electrodynamics	27 7/8	21	25
DuMont Labs.	10	6	6 1/4
ElectroData	20	13 1/2	19
Fairchild Camera & Instr.	25 1/4	19 1/2	22 7/8
Int'l Resistance	8 1/4	6 3/8	6 3/8
Lear Inc.	10 1/4	7 1/2	8
Nat'l Res. Corp.	29 3/4	17 7/8	23
Neptune Meter	34 7/8	28 3/8	30 1/2
New Haven Clock	2 1/2	1 1/2	1 5/8
Norden-Ketay	14 7/8	10 1/2	11
Pneumatic Scale	28 1/4	25	25 - 26 (1)
Servomechanisms	9 1/2	8 1/4	8 7/8
Wallace & Tiernan	22 1/2	19 5/8	20
Waltham Watch	3	1 7/8	1 7/8

(1) Bid - Asked price, no sale.

Instruments for Precision Measurements

AP-11 is rated at 1/2 of 1%

AP-12 is rated at 1/4 of 1%

GENERAL ELECTRIC ANNOUNCES . . .

NEW PORTABLES WITH 3 BIG ADVANTAGES

New AP-11 and AP-12 portables give you sustained high accuracy, convenience of use, and high scale readability for precise measurements in a wide variety of applications.

Newest Additions to the expanded line of General Electric portable instruments are the high-accuracy AP-12 for precise a-c/d-c measurements and the AP-11 for general a-c measurements. The new AP-12 is designed to replace the well-known General Electric type P-3 instrument.

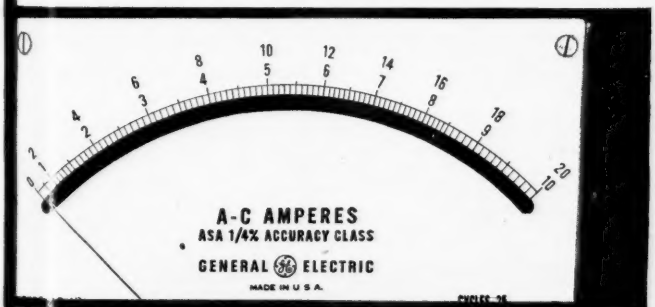
You Get Three Big Advantages for precise measurements. Sustained high accuracy comes from spring-mounted jewel bearing design which avoids pivot blunting. Convenience of use comes from universal terminals and rugged, lightweight Textolite* plastic cases. High readability comes from nearly uniform scale distribution. This is especially true at lower ends of scales.

For High-accuracy Testing, the new AP-12 for a-c/d-c and the matching DP-12 for d-c are rated at ¼ of 1% of full-scale values. Both instruments are ideal for laboratory, central station, factory, and field applications.

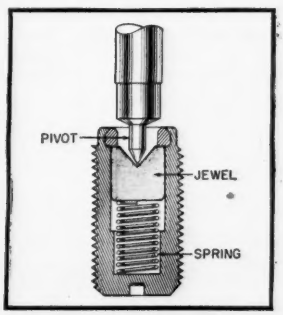
For General Testing, the AP-11 for a-c/d-c and the matching DP-11 for d-c are rated at ½ of 1% of full-scale values and provide accurate measurements in electric utility, contractor and repair shop applications. Small-size types AP-9 for a-c (rated at ¾ of 1%) and DP-9 for d-c (rated at ½ of 1%) are also available.

*Reg. trade-mark of General Electric Co.

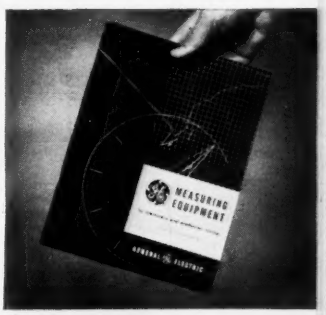
LOOK AT THE FEATURES IN G-E PORTABLES TO ASSURE PRECISE MEASUREMENT.



MORE UNIFORM SCALE DISTRIBUTION is now possible for high-accuracy a-c measurements. Note how much more precisely readings can be made, especially at lower end of scale. New window admits light from three sides.



SPRING-MOUNTED JEWELS cushion pivots to avoid pivot blunting and jewel cracking.

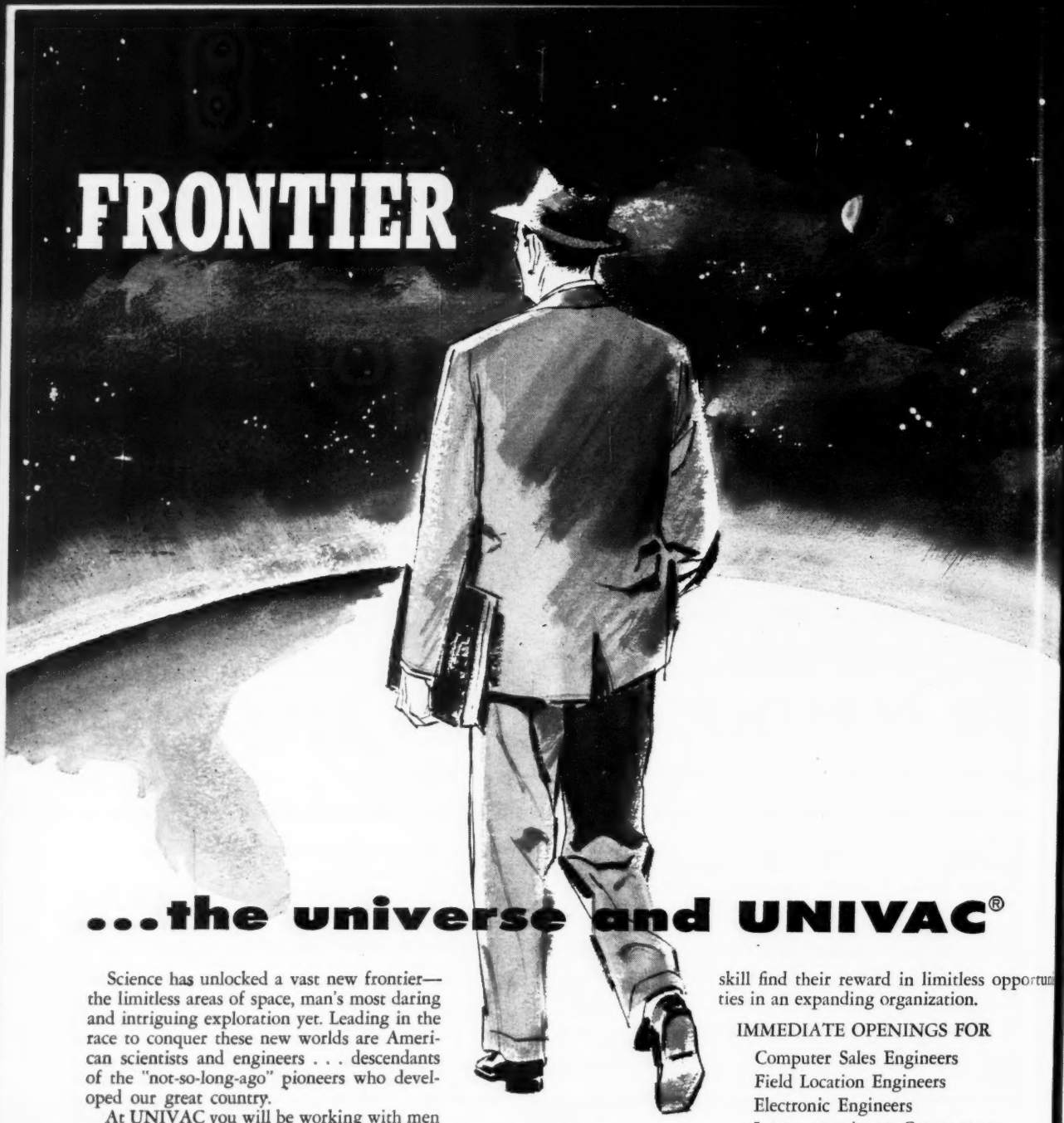


WRITE FOR BULLETINS—Ask for GEC-979, GEC-1384 and instrument catalog GEC-1016.

FOR FULL INFORMATION, WRITE SECTION 582-18, GENERAL ELECTRIC CO., SCHENECTADY 5, N. Y., OR CONTACT YOUR NEAREST G-E APPARATUS SALES OFFICE.

GENERAL ELECTRIC

For more information circle **33** on inquiry card.



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Science has unlocked a vast new frontier—the limitless areas of space, man's most daring and intriguing exploration yet. Leading in the race to conquer these new worlds are American scientists and engineers . . . descendants of the "not-so-long-ago" pioneers who developed our great country.

At UNIVAC you will be working with men who developed much of the basic knowledge of computers—who designed and produced components being used by other manufacturers in the field. Univac has set the standards that others follow.

Now is the time to come to Univac where ambition and professional skill find their reward in limitless opportunities in an expanding organization.

IMMEDIATE OPENINGS FOR

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St. Paul W4, Minn.

Mr. Cal Bosin
Dept. YJU-27
315 Fourth Ave.
New York City

® Registered in U. S. Patent Office

New Plants and Mergers

CONSOLIDATED ELECTRODYNAMICS CORP. announces completion of their new, three-story, $1.5 million research, engineering and marketing building in Pasadena. The entire building is air-conditioned and areas devoted to engineering and research are soundproofed and separated from supporting activities. Two acres of the eight-acre site have been reserved for future expansion.

BARTON INSTRUMENT CO. will have its new 30,000-sq-ft, $200,000 air-conditioned building completed in

July. Construction is tilt-up concrete slab; 53,000 sq ft of paving is planned for parking.

BECKMAN INSTRUMENTS, INC., announces acquisition of Lou-Bar Products, manufacturer of precision components for automatic control systems.

TEXAS INSTRUMENTS, INC. announces an agreement to acquire the Wm. I. Mann Co., producer of precision optical components.

FISHER GOVERNOR COMPANY announces appointment of J. G. Chilcoat and Co., Pgh., Pa., as their sales representative for W. Pa. and W. Va.

THE RAMO-WOOLDRIDGE CORP. is building the initial unit of their nine-building Research and Development Center near the Los Angeles International Airport.

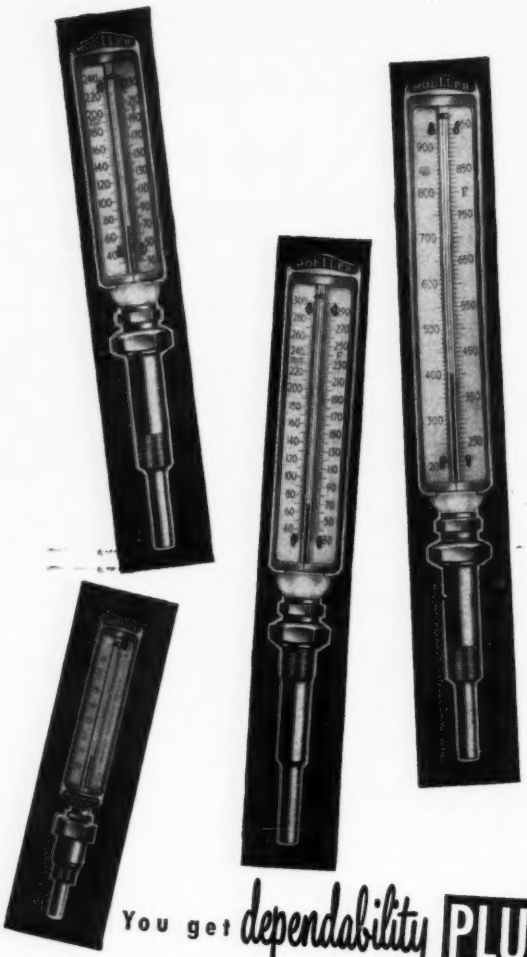
MINIATURE PRECISION BEARINGS, INC., has opened its new plant at Keene, N.H. for production of miniature ball bearings.

BARBER-COLMAN CO., Wheelco Instruments Div., announces appointment of Instruments, Inc. as exclusive representative for Wheelco Industrial Instruments and Combustion Safeguards in the Tulsa area.

HEWLETT-PACKARD CO. expansion program is well under way with the first unit of the six-building project slated for mid-winter occupancy. Nothern and eastern Ohio and western Pa. has been added to the territory of S. Sterling Co., representatives.

BURROUGHS CORP. announces opening of two new labs in suburban Phila., a $1.5 million investment to

EPLAB
Thermopiles
For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.
This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.
All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.
If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.
*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.
BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.
THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
NEWPORT, RHODE ISLAND, U. S. A.



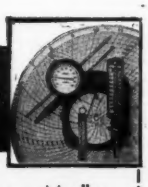
You get dependability PLUS

in Moeller Industrial Thermometers

because our business has been the design and manufacture of temperature measuring instruments since 1867.

Moeller Industrial Thermometers are made in any form—straight angle, right or left side angles, reclined or inclined angles, in scale ranges of —120°F to plus 1125°F or in centigrade equivalents. Available in 5", 7", 9" and 12" scale sizes with plain stems, union connection stems and separable sockets in all stem lengths and alloys. *Mail the coupon today for detailed information.*

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities



Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Industrial Thermometers.

NAME .....

FIRM .....

ADDRESS .....

CITY ..... ZONE ..... STATE .....

For more information circle **35** on inquiry card.

PLANTS—CONT.

supplement the Central Laboratory's electronic research and development program.

BORG-WARNER CORP., BJ ELECTRONICS, announce that all four BJ Electronics plants began operations in a single, new, Santa Ana plant that more than doubles their former working space.

NATIONAL CASH REGISTER CO. has dedicated its 52,000-sq-ft Electronics Div. structure devoted to research

and design in advanced electronic computers for business systems.

COMPUTER-MEASUREMENTS CORP. announces the following new representatives: L & M Assocs. for N.Y., L.I., N.J., and E. Pa.; M.P. Odell Co. for Ohio, E. Mich., N. W. Va., and W. Pa.; Mitchell Spears Co. for Texas and Okla.

AMERICAN RESEARCH CORP. recently broke ground for their new 8500-sq-ft plant in Farmington, Conn.

AMERICAN MACHINE & FOUNDRY CO., Sterling Engineering Div., has been made a subsidiary of Potter & Brumfield, Inc. to coordinate activities of the two manufacturers of relay switches.

THE GAMEWELL COMPANY announces new precision potentiometer representation. N. Ohio and W. Pa. will be covered by newly formed Electro-Sales Assocs., Inc.; Luscombe Engineering Co. will handle West Coast.

G. M. GIANNINI & CO., INC., Electromechanical Div., has a new air-conditioned building for engineering, development and production of electromechanical products.

PERKIN ENGINEERING CORP. has added the territory of N. Calif., Arizona and Nevada to McCarthy Associates.

CONCORD CONTROL, INC., Cambridge, Mass., has been formed to specialize in the development and manufacture of numerical control equipment for machine tools and industrial processes.

HYCON MFG. COMPANY has established a new Camera and Instrument Div. to consolidate photographic and special products.

WHEELCO INSTRUMENTS DIVISION, Barber-Colman Co. announces establishment of a branch office in Houston, Texas.

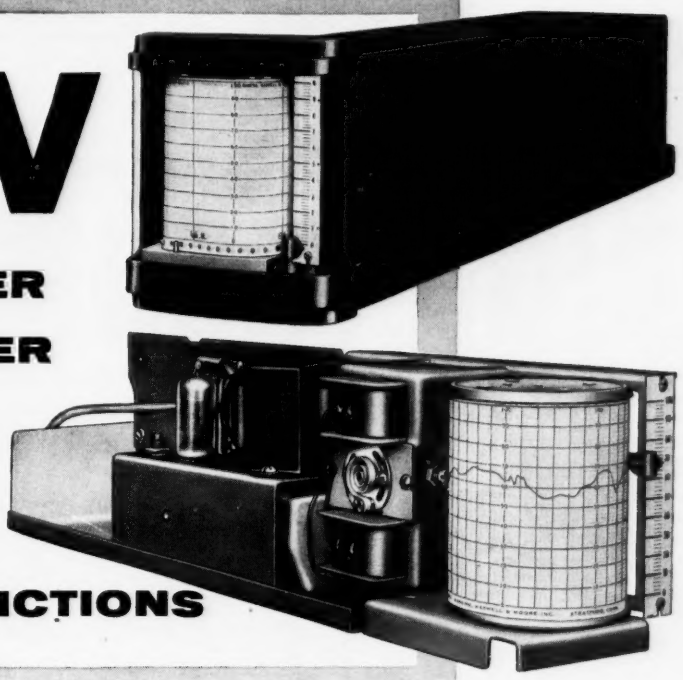
TEXAS INSTRUMENTS, INC. announces combination of their Semiconductor Products and Components divisions.

NON-LINEAR SYSTEMS INC., Del Mar, Calif., announces appointment of Robert A. Waters Inc., Wayland, Mass., as their New England representative.

REEVES INSTRUMENT CORP. announces sales operations in the Greater New York area will be conducted from their new office at 215 E. 91 st., New York 28, N. Y.

NEW

MICROAMMETER
MILLIVOLTMETER
RECORDER
PERFORMS 6
ESSENTIAL FUNCTIONS



★ **Measures low-level dc signals with calibration accuracy within 0.5%, and sensitivity within 0.2% of span.**

★ **Records on 3" continuous strip chart or IBM-type card chart, with linear coordinates.**

★ **Positions recording pen with force many thousand times greater than usual direct-deflection electrical movements.**

★ **Operates on force-balance principle compensating for ambient conditions, changes in power supply and components.**

★ **Gives high-speed recording — up to 0.05 seconds for 63% of fullscale changes.**

★ **Provides span and zero adjustments for ease of calibration and zero suppression in the field, without special equipment.**

The new 'American-Microsen' Series 130 Recorder is a highly sensitive microammeter or millivoltmeter that gives positive, accurate electrical measurement and rugged, maintenance-free service. Yet the unit costs less than other recorders for the same purpose.

Heart of the Series 130 Recorder is the "Microsen" balance that converts low-level dc input signals into powerful output current to drive the recording pen. Pen position is fed back to the input. Consequently, the recording unit is force-balanced in precise relationship with the input signal. Power is ample to operate alarm contacts, which are available.

SPECIFICATIONS

POWER SUPPLY: 115 volts, 60 cycles. **POWER REQUIREMENT:** 9 watts

INPUT RANGES: Voltage – 0-20 millivolts to 0-100 volts dc. **Current** – 0-200 microamperes to 0-100 milliamperes dc. **Input Sensitivity** – 6700 ohms per volt.

ACCURACY: ± 0.5% of span. **SENSITIVITY:** ± 0.2% of span. **REPEATABILITY:** ± 0.25% of span.

EFFECT OF SUPPLY VOLTAGE: Less than 0.5% error 90-130 volts.

EFFECT OF AMBIENT TEMPERATURE: Less than 0.5% error 50° to 100° F., and less than 1% to 130° F.

RESPONSE TIME: Fast Speed – 0.2 seconds standard for 63% of fullscale input change; up to 0.05 seconds for 63% on special order. **Slow Speed** – approximately 4 times fast speed setting.

SHOCK RESISTANCE: Withstands shock up to 30 times gravity.

CHART SPEEDS: Strip Chart – 1" per hr., standard; 3" or 6" per hr. available. **Card Chart** – 1 rotation per day, standard.

SPAN ADJUSTMENT: ± 10% of span. **ZERO ADJUSTMENT:** ± 100% of span.

PRICE: $250.00 consumer net for standard models.

Write for Bulletin MG10

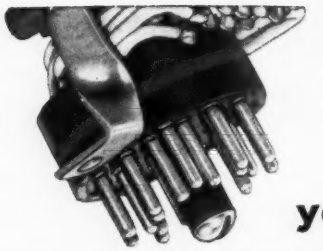
MANNING, MAXWELL & MOORE, INC.

INDUSTRIAL CONTROLS DIVISION, STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC TRANSMITTERS, INDICATORS, RECORDERS, CONTROLLERS, ELECTRO-PNEUMATIC VALVE POSITIONERS AND ELECTRO-HYDRAULIC CONTROL VALVE OPERATORS.

MANNING MAXWELL & MOORE INC. TRADE MARK

For more information circle **36** on inquiry card.



you can have the advantages of

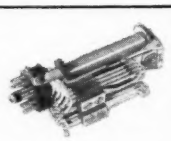
plug mounting

in all these Automatic Electric

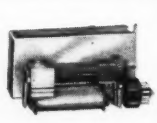
relays

CLASS A:
The "all-purpose" relay for use where first cost is important. Gives long, dependable service. Size: 4⅜" x 2³⁄₁₆" x 1⁷⁄₁₆".

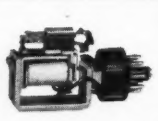
CLASS B:
Made for extremes of long service life and dependability — often exceeding 400 million operations! Size: 4⅜" x 2³⁄₁₆" x 1¼".



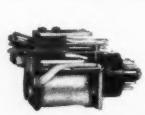
CLASS F:
Low operating power makes this relay especially desirable in a.c. circuits where relays function without specified operate or release time delays. Size: 4⅝" x 1¹⁵⁄₁₆" x 1¼".



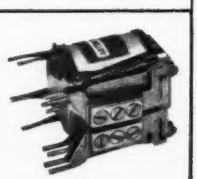
CLASS S:
Made for exacting miniature requirements. Used in aircraft where resistance to shock and vibration is needed in a small, light, reliable relay. (For printed circuit applications—see below.) Size: 2⁹⁄₁₆" x 2" x 1¼".



CLASS Z:
Provides maximum timing in a "small-as-possible," low-cost relay. Compact, light, resistant to shock and vibration. Size: 3¼" x 2⅞" x 1¹³⁄₃₂".



"PLUG-IN" RELAY FOR PRINTED CIRCUITS
Design of coil and spring terminals permits direct insertion into printed circuits with high-conductance connections, easily soldered. Bearing design gives up to 120 million operations without readjustment or relubrication. Size: 1¾" x 1⅛"-1¾" (depending upon number of contact springs) x 1".



For any application, you can choose an Automatic Electric relay—a top-quality relay in every way—with the additional advantages of *plug mounting:*

Minimized inventory—When you standardize on plug-in relays, you can often interchange the same basic relay in many models of your equipment. Thus, you make substantial savings by reducing your inventory costs, speeding assembly.

Fast, simplified inspection and maintenance—Plug-in relays permit periodic bench inspections with almost no "down time" involved. Entire banks of relays can be removed for testing, and then replaced, in *seconds.*

Simplified replacement—Plug-mounted relays can be replaced quickly and easily at otherwise inaccessible points in your equipment. Even an unskilled service man can replace relays in a matter of seconds without tampering with circuit wiring.

You can select Automatic Electric plug-in relays from five basic types and thousands of individual assemblies.

Send for Relay Circulars 1800—1804—They give complete specifications, dimensional drawings, and helpful information. *Address* Automatic Electric Sales Corporation, 1033 West Van Buren Street, (HAymarket 1-4300) Chicago 7, Illinois. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

AUTOMATIC ELECTRIC

Originators of the dial telephone · Pioneers in automatic control

GENERAL TELEPHONE SYSTEM

For more information circle **37** on inquiry card.

People IN THE NEWS

CONSOLIDATED ELECTRODYNAMICS CORP., Pasadena, announces appointment of *William F. Johnson* as director of sales, *Russell R. Palmer* as manager of sales operations, and *Linden G. Criddle* as manager, Special Products Div.

W. F. Johnson
CEC

D. E. Moat
L & N

LEEDS & NORTHRUP CO. announces appointment of *Donald E. Moat* to position of director of marketing, and *G. Lupton Broomell Jr.* as assistant director of engineering, acting head of engineering and inspection depts., and member of the executive operating committee.

RICHARDSON SCALE CO., Clifton, N. J., has named *Walter M. Young* director of sales.

UNDERWOOD CORP. *Albert A. Auerbach* has been named chief engineer of the company's Electronic Computer Div.

FENWAL INC., Ashland, Mass. *James R. Keough* has been appointed manager of manufacturing, and *E. Sohier Welch* chief research engineer.

TEXAS INSTRUMENTS INC. *Dr. John A. F. Gerrard* is now director of geophysical research in the central research division. New promotions within the apparatus division include; *Cecil L. Covington*, controller; *R. E. Houston*, personnel director; *W. H. Owen*, chief industrial engineer; and *Ingram Lee II*, production manager.

EECO PRODUCTION CO. announces appointment of *Theodore W. Jarmie* as vice president and general manager.

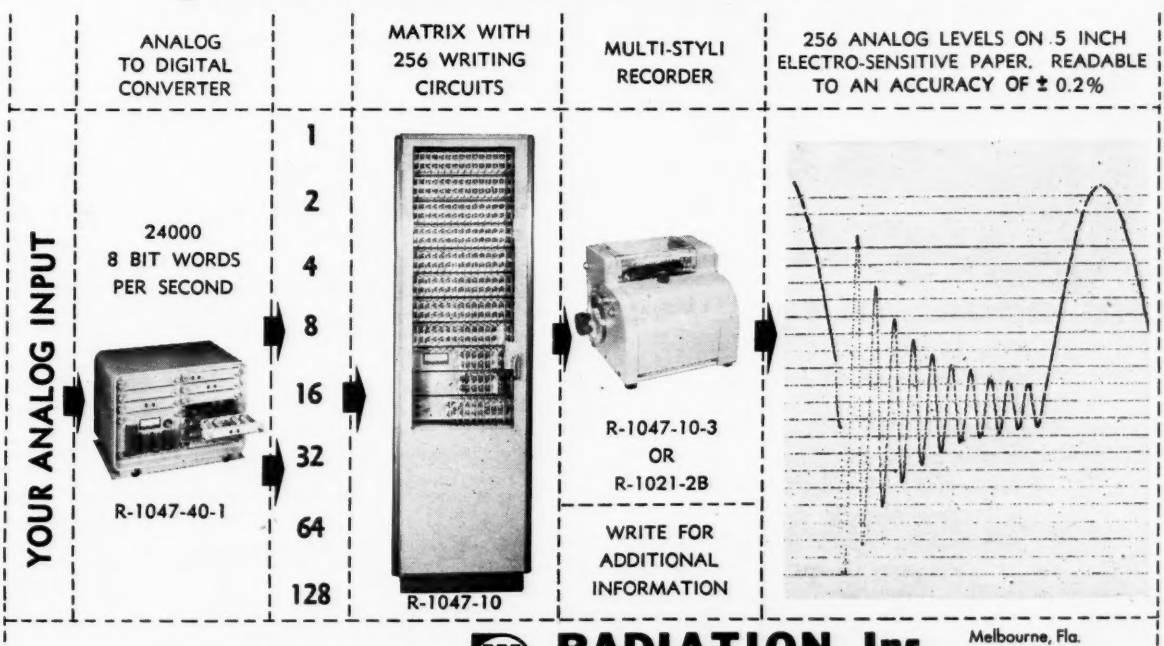
T. W. Jarmie
EECO

J. C. Koch
Conoflow

CONOFLOW CORP., Phila., Pa. *John C. Koch*, vp and general manager of Conoflow and president, Phila. Section, ISA, has been elected president of The Fluid Controls Institute, Inc.

NATIONAL BUREAU OF STANDARDS announces *Dr. Lewis V. Judson*, chief of the length section of the optics and metrology division, has been given the Department of Commerce Silver Medal for Meritorious Service.

QUICK-LOOK RECORDING SYSTEM



PERSONNEL INQUIRIES INVITED

RADIATION Inc. Melbourne, Fla. Orlando, Fla.

Electronics • Avionics • Instrumentation

For more information circle **38** on inquiry card.

OFFICE AUTOMATION conference for SENIOR EXECUTIVES

New Yorker Hotel

Co-sponsored by

FORDHAM UNIVERSITY SCHOOL OF BUSINESS

and the

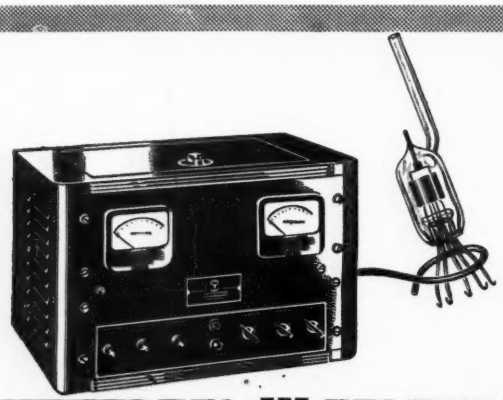
THIRD INTERNATIONAL AUTOMATION EXPOSITION

November 26, 27

- ► Managed by GORDEN L. MATTSON, office automation consultant and director of the first conference.
- ► Objective: to provide top management with information to guide them in making use of automation in data processing, etc.
- ► 8 sessions.

Write: RICHARD RIMBACH ASSOCIATES, INC.
Room 359, 525 Lexington Avenue
New York 17, New York

For more information circle **81** on inquiry card.



THE MODEL III TELEVAC

An Indicating Ionization Gauge for precise pressure measurements between 10^{-3} and 10^{-8} mm. mercury.

DESIGN IMPROVEMENTS INCLUDE:

- Elimination of zero drift
- Improved protective circuit
- Improved degassing circuit
- Completely stabilized power supply
- Linear Response

WRITE

George E. Fredericks Co.
BETHAYRES • PENNSYLVANIA

For more information circle **39** on inquiry card.

PEOPLE—CONTINUED

THE SWARTWOUT CO. has appointed *J. R. Walchli* as product manager of the southeastern regional office for the Autronic Process Controls Div.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has appointed *Glenn E. Seidel* to the newly-created position of vp in charge of engineering.

NORDEN-KETAY CORP. *Perry R. Roehm* was elected to succeed *Morris F. Ketay* as president on June 1, 1956.

BENDIX AVIATION CORP., Computer Div., Los Angeles, has appointed *O. Paul Staderman* director of marketing for the Computer Division.

ROBERTSHAW-FULTON CONTROLS has appointed *Charles D. Branson* as assistant director of research. *George L. Leupold* has been appointed assistant general sales manager of the Fulton Sylphon Div.

C. D. Branson
Robertshaw-Fulton

C. E. Balz
Burgess

BURGESS BATTERY CO. *Charles E. Balz*, sales manager, has been named vice president for sales.

HYCON MFG. CO., Pasadena, has appointed *William C. McFadden* as executive vice president.

BAUSCH & LOMB OPTICAL CO. has elected *Alton K. Marsters* as vice president in charge of sales.

AMPHENOL ELECTRONICS CORP. announces appointment of *Dr. Rodolfo M. Soria* to vice president of engineering.

DR. JOHN VON NEUMANN, AEC Commission, is the first recipient of the Enrico Fermi Award comprising a medal, citation and $50,000, made in recognition of Dr. von Neumann's contributions to theory and construction of computing machines.

AMERICAN METER CO., INC., Phila., has named *Robert R. Troyer* as assistant to the advertising manager, and *Richard E. Martin* as sales-engineer for the Pittsburgh sales district.

POWERS REGULATOR CO., Skokie, Ill., announces election of *Kenneth M. Stevens* as a director. *Harold C. Mueller*, president, has been elected president of the Illinois Tech Alumni Association.

In Memoriam

JOSEPH F. TAYLOR, chairman of the board, Bausch & Lomb Optical Co., passed away June 13 at the age of 67 following a prolonged illness.

CARL W. JOHNSON, senior vice president of Clevite Corp. since 1948, died on June 5, 1956.

new!

P-T-F Digital Indicator

• another new digital systems component by BJ Electronics-Borg-Warner

• specifically engineered for use with BJ Vibrotron Digital Gages

1. Indicates measurement signals from remote Vibrotron digital sensing gages directly in numbers.
2. Pressure, temperature or flow measurements are indicated directly in absolute or percent full scale numbers.
3. Visual read-out is provided from 000 to 999 in steps of 0.1 for a percentage type indication allowing maximum utilization of digits.
4. May be used with printer or electric typewriter for permanent digital recording.
5. Supplementary memory feature... see below.

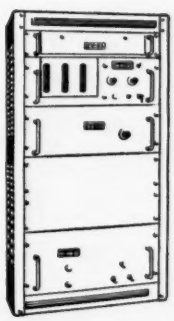
BJ VIBROTRON DIGITAL GAGE

The heart of BJ digital systems is the patented Vibrotron gage. This electronic sensing device utilizes a vibrating wire which is tuned by an element sensitive to pressure, temperature or flow. The Vibrotron gage generates its own precision measurement frequency signals which can be transmitted by radio link or direct wire without loss of accuracy.

Make your systems count! This new P-T-F Digital Indicator is one of a group of BJ digital systems building blocks engineered to indicate, record and control pressure, temperature or flow operations.

The P-T-F Digital Indicator and its auxiliary Memory File are designed for standard relay rack mount or can be individually cased.

For full information on these and other new BJ-Borg-Warner products, write for the special technical file "Make Your Systems Count."



BJ MEMORY FILE

This companion unit allows the BJ Digital Indicator read-out to be set to any desired base number (such as 000) ... and retains this base as a digital constant.

BJ ELECTRONICS

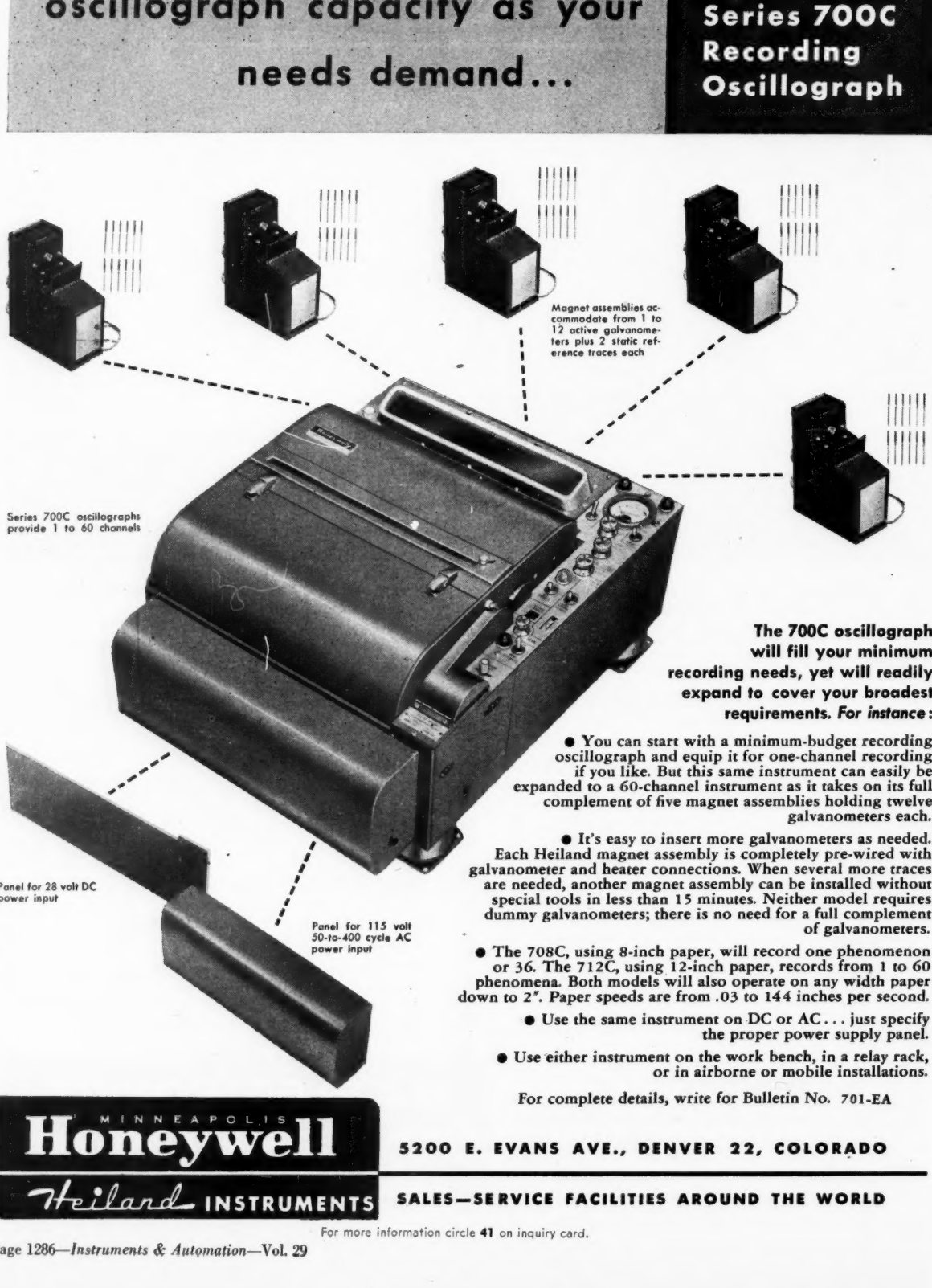
BORG-WARNER CORPORATION

3300 Newport Boulevard • Santa Ana, California

For more information circle **40** on inquiry card.

expand your oscillograph capacity as your needs demand...

with the HEILAND Series 700C Recording Oscillograph


Magnet assemblies accommodate from 1 to 12 active galvanometers plus 2 static reference traces each
Series 700C oscillographs provide 1 to 60 channels
Panel for 28 volt DC power input
Panel for 115 volt 50-to-400 cycle AC power input

The 700C oscillograph will fill your minimum recording needs, yet will readily expand to cover your broadest requirements. *For instance*:

- You can start with a minimum-budget recording oscillograph and equip it for one-channel recording if you like. But this same instrument can easily be expanded to a 60-channel instrument as it takes on its full complement of five magnet assemblies holding twelve galvanometers each.
- It's easy to insert more galvanometers as needed. Each Heiland magnet assembly is completely pre-wired with galvanometer and heater connections. When several more traces are needed, another magnet assembly can be installed without special tools in less than 15 minutes. Neither model requires dummy galvanometers; there is no need for a full complement of galvanometers.
- The 708C, using 8-inch paper, will record one phenomenon or 36. The 712C, using 12-inch paper, records from 1 to 60 phenomena. Both models will also operate on any width paper down to 2". Paper speeds are from .03 to 144 inches per second.
- Use the same instrument on DC or AC . . . just specify the proper power supply panel.
- Use either instrument on the work bench, in a relay rack, or in airborne or mobile installations.

For complete details, write for Bulletin No. 701-EA

MINNEAPOLIS **Honeywell**

Heiland INSTRUMENTS

5200 E. EVANS AVE., DENVER 22, COLORADO

SALES—SERVICE FACILITIES AROUND THE WORLD

For more information circle **41** on inquiry card.

SIGNIFICANCE

In this "Biographies of Significance" feature you have met leaders in instrumentation in the fields of research, petroleum plant operation, analog computation, aviation, and oil and gas distribution. This month you will learn what type of man supervises the instrumentation associated with plant engineering, design and construction.

The Fluor Corporation, Ltd. of Los Angeles both engineers and constructs plants—chemical, rubber, petroleum, power generation, atomic, etc. Glen Gallagher is Principal Instrument Engineer for Fluor—a key position within a key field of instrumentation.

He has made pioneering contributions in all fields today considered as the frontiers of modern process instrumentation—graphic panels, electronic control systems, automatic process data loggers, etc. He is President of the SCMA and a charter and active member of the ISA.

We are pleased this month to introduce you to Glen C. Gallagher, and to acknowledge his outstanding contributions to the field of Instrumentation.

Glen Gallagher, principal instrument engineer of The Fluor Corporation, Ltd., compares a model of control center of the future with a present-day control center.

GLEN G. GALLAGHER

Glen G. Gallagher was born October 9, 1909, in Palmer, Indiana. He attended a technical high school in Hammond, Indiana, gaining early experience in mechanical and electrical equipment by taking automotive and electrical courses. Later he took a correspondence course in electrical engineering and evening courses in mathematics and industrial instrumentation from Purdue, Indiana, and Southern California universities.

He obtained his first experience in mechanization or mass production as a mechanic, working for the Ford Motor Co. in the Chicago area in 1929. For its day, this plant was highly mechanized and assembled 600 of the first Model A Fords per eight hour day—one every 45 seconds. This experience probably provided the background that guided Glen's later life into instrumentation and automation.

In September of 1929 he made his first contact with the petroleum industry, an industry he is still associated with indirectly. This contact was with Cities Service Oil Co. at East Chicago, Indiana. He worked on the construction of this plant as an electrician, installing instruments and control equipment. When the plant was completed, he transferred to operation as an instrument mechanic, and eventually as head of the instrument department. He was in charge of all instrument maintenance and repair in a plant that was considered ultra modern in those days—with $50,000 worth of instruments.

In 1937 he joined Universal Oil Products Co. in Chicago as a field instrument engineer. For the next 5 years he worked on instrument and control problems in some 70 refineries in the United States, Canada, Mexico, Trinidad.

After Pearl Harbor, he was brought in to Chicago headquarters to head up the Instrument Application and Engineering Section of UOP. In this capacity he directed and trained many instrument engineers in the application of instruments and controls to a great number of petroleum processes. Many of these were for the manufacture of aviation gasoline for the war effort. As the plants were completed, he and the other instrument engineers went to the field to assist in the start up of these plants. As a result, much valuable "feedback" of information was obtained to improve future plants.

In 1948, Glen joined the Fluor Corporation, Ltd., in Los Angeles as Principal Instrument Engineer, a position he holds today. In this assignment he gained additional experience in the control of petroleum plants, as well as branching out into the control of chemical plants, steam-electric power plants, and atomic reactors. During his first five years

Engineers • Physicists

Both Defense and Industry Demand Specialists...

And, — here in BURROUGHS three ultra-modern Research Laboratories, such men who are truly dedicated to their profession are pursuing extensive basic and applied research programs . . . developing new Computing, Information Handling and Data Processing equipment to keep pace with our ever-expanding economy . . . providing BOTH business and government with the most efficient and effective electronic machinery ever devised by man.

Included in the many areas of research and development now under way are such well known governmental projects as —

IRBM • ICBM • SAGE

We have proved our abilities to handle such tasks as well as many other far reaching assignments. Today's demands for Engineers and Physicists are, therefore, based on a need to further supplement our efforts in these and allied fields.

LOOKING TO FUTURE EXPANSION

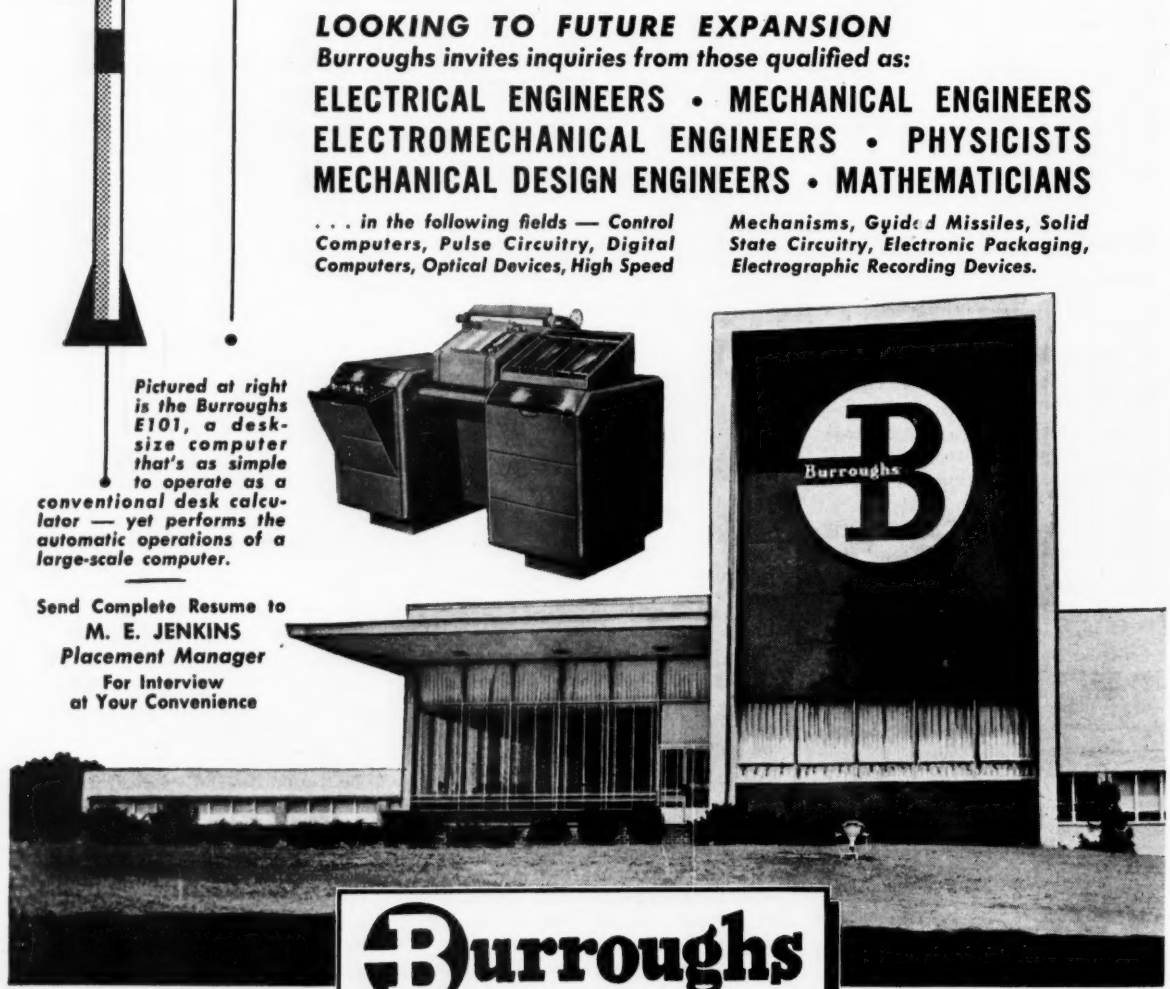
Burroughs invites inquiries from those qualified as:

ELECTRICAL ENGINEERS • MECHANICAL ENGINEERS
ELECTROMECHANICAL ENGINEERS • PHYSICISTS
MECHANICAL DESIGN ENGINEERS • MATHEMATICIANS

. . . in the following fields — Control Computers, Pulse Circuitry, Digital Computers, Optical Devices, High Speed Mechanisms, Guided Missiles, Solid State Circuitry, Electronic Packaging, Electrographic Recording Devices.

Pictured at right is the Burroughs E101, a desk-size computer that's as simple to operate as a conventional desk calculator — yet performs the automatic operations of a large-scale computer.

Send Complete Resume to
M. E. JENKINS
Placement Manager
For Interview at Your Convenience



The FOREMOST NAME In Computation

Burroughs
CORPORATION
RESEARCH CENTER
PAOLI, PA., NEAR HISTORIC VALLEY FORGE

BURROUGHS MEANS BUSINESS

BIOGRAPHIES—CONT.

in this assignment the Instrument Section also handled hydraulics, which included all line sizing and pressure-drop calculations.

Because of his strong practical background, Gallagher has forged an Instrument Engineering Section of wide versatility at Fluor. His men are not only responsible for office engineering, but also perform control system check-outs and calibration in the field, and assist with start ups. The wide experience and capabilities he has cultivated in his men make it possible for Fluor to turn over operating, controllable complex plants to their customers.

Presently, he is supervising 20 instrument engineers responsible for all measurement and control, including relief valves and safety systems. He was one of the early pioneers in the design of graphic panels, and largely responsible for the first all-electronic transmission and control system being installed in a West Coast refinery about two years ago.

His group at Fluor is now pioneering the application of automatic data logging and scanning to process industries. This is a field in which Glen has been interested since his early days with Universal Oil Products.

He has also had a guiding hand in the development of many important instruments and instrument techniques. Notable among these is the "Vapor Pressure Controller" for fractionating columns. Another first to his credit is the introduction of hydraulic systems as the control medium for butadiene dehydro plants. In one plant, as much as one half million dollars were saved by using hydraulic operators, rather than using the electric motor operators which had been considered standard on these plants for many years.

Glen is a registered professional engineer in California; a charter member of the Instrument Society of America; member of the I.S.A. Recommended Practices Committee, and chairman of its "Instrument Specification" Sub-Committee. He has also served on the Steering Committee of the A.S.M.E., Instruments and Regulators Division. At present, he is president of the Southern California Meter Association.

Glen has also contributed considerably to instrument literature by writing or co-authoring the following papers; (1) "Minimizing Instrument Maintenance in Designing Aviation Gasoline Plants" (with Dr. D. J. Bergman), A.S.M.E., New York 1943; (2) Chicago Production Show paper (1945); (3) "Control of Narrow Boiling Fractionating Columns," I.S.A., Chicago (1947); (4) "Graphic Instrumentation and Installation," S.C.M.A., Los Angeles 1951; (5) "What's New in Centralized Instrumentation in the Process Industries," A.S.M.E., Los Angeles 1952; (6) "Trends in Modern Instrumentation," C.N.G.A., Los Angeles 1953 and *Instruments & Automation*, Jan., 1954; (7) "Automation, Friend no Foe," Fluor-O-Scope, Los Angeles, July-August 1955; (8) "Future Trends in Automation" (with R. A. Robinson), A.S.M.E., New Orleans, 1955; *Instruments & Automation*, Feb., 1956.

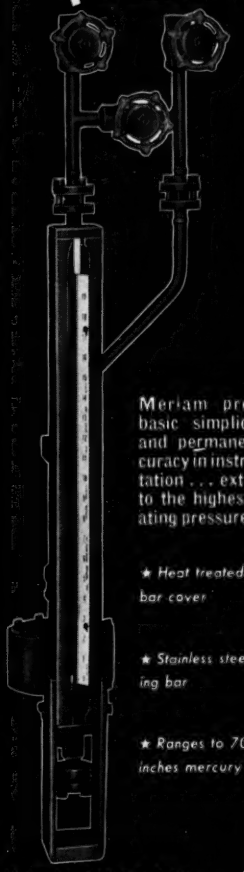
Glen tells us, "I saw my first copy of *Instruments* magazine in 1930, and have been a very faithful reader of it, from that day on.

"In the three companies that I have worked for, I have always seen that *Instruments and Automation* was circulated to all members of the Instrument Section. In addition, I might add that of the twenty-one Instrument Engineers here at Fluor, fifteen get their own copy."

UNMATCHED ACCURACY

at highest working pressures

At pressures up to 2000 psi, this Meriam Manometer provides critically accurate flow or differential pressure measurement. Constructed of solid bar stock steel, all parts are precision fitted, hand lapped. Each unit is cold hydraulic tested to 5000 psi.



Meriam provides basic simplicity... and permanent accuracy in instrumentation... extending to the highest operating pressures.

★ Heat treated glass bar cover

★ Stainless steel backing bar

★ Ranges to 70 inches mercury

Write for Bulletin C-12.

Meriam Manometer Instrumentation ...for pressures, vacuums, flows, liquid levels.

meriam

INSTRUMENT COMPANY

10920 Madison Ave. • Cleveland 2, Ohio

For more information circle **42** on inquiry card.

BALZERS Thin Film Optics

From the Principality of Leichtenstein Swiss Customs Area

ROLYN ARCADIA (Calif.)

Front Surface Mirrors, Cold Mirrors, Achromatic Beam Splitters, Dichroic Beam Splitters, Monochromatic Interference Filters, Wedge Interference Filters, Heat-Reflecting Interference Filters, Cut-Off Filters, Anti-Reflection Coatings, Heat Protective Coatings and many other thin layers.

CABLE ADDRESS "ROLYN" LOS ANGELES
PHONE: DOUGLAS 7-2300

Robert M. Lynn

(ROLYN COMPANY) -- ESTABLISHED 1923

OPTICAL—GLASS—PHOTO

319 North Santa Anita Ave. • Arcadia, California

ADDRESS REPLY TO P. O. BOX 745 ARCADIA, CALIFORNIA

Balzers means research in high vacuum process

For more information circle **150** on inquiry card.

Non-Habit-Forming

Pressure gage courtesy J. E. Lonergan Co., Philadelphia 6, Pa.

Beryllium Copper Tubing by Superior

This unusual term describes perfectly one of the most important properties of beryllium copper tubing. The Bourdon tube shown above is an excellent example. Once the beryllium copper tube is in the gage, it "remembers" its job and acquires no new habits. It yields constantly to pressure and as constantly returns to its original position without taking a new "set."

Beryllium copper tubing by Superior has this and many other important characteristics to a marked degree, such as hardenability, corrosion and fatigue resistance, thermal and electrical conductivity. It is easy to fabricate, it is nonmagnetic.

Beryllium copper tubing lends itself to a wide variety of applications. It can be severely worked to form convoluted flexible waveguides and bellows. Cold drawn to specifications, followed by proper hardening, it makes an excellent aircraft antenna, with the strength to withstand thousands of hours' vibrating in 100 mph winds. Used as a contact roll in a business machine collator, it is wear and corrosion-resistant, and a good electrical conductor. Or, as above, shaped for use as a Bourdon tube, it is tough, ductile, durable—and holds its original shape.

Superior produces tubing in over 63 analyses . . . in stainless, alloy and carbon steels, nickel and nickel alloys, beryllium copper, titanium and zirconium. Let Superior's tubemanship and experience help you solve your tubing problems. You'll like the service and the products—they *are* habit-forming. Send for your free copy of Data Memorandum No. 7 on beryllium copper tubing. Write Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

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INSTRUMENTS and AUTOMATION Books

Standards for a Strong America. 1954. American Standards Association, New York 17, N. Y. 97 p., unbound. $3. Papers at fifth National Conference on Standards, and 36th annual meeting of American Standards Association.

Electrometric *p*H Determinations; Theory and Practice, by Roger G. Bates. c1954. John Wiley & Sons, New York 16, N. Y., 331 p. $7.50. 9¼ in. Purpose is (1) to present the theoretical basis for an electrometric scale of acidity, and (2) to offer a practical handbook of experimental aspects of determination.

Introduction to Physics, by Frank M. Durbin. 1955. Prentice-Hall, 70 Fifth Ave., New York, N. Y. 780 p. 9¼ in. First course for college students, including review of algebra and geometry. About one-third of the book is devoted to "modern" physics.

Kleines Handbook Technischer Regelvorgange, by Winfried Oppelt. 1954. Verlag Chemie, G.m.b.H., Weinheim/Bergstr. 447 p. DM 31.80. Manual of automatic control with introduction to mathematical treatment, and chapters on the controlled system, the automatic controller, the control loop, the multi-loop control system, and discontinuous control action.

Laboratory Instruments; Their Design and Application, by A. Elliott and J. Home Dickson. 1953. Chemical Publishing Co., New York 10, N. Y. 414 p. $7.50. 8½ in. Considerable attention to glass, metals and plastic materials for construction of instruments. Chapters on sensitivity and errors, and on isolation of instruments from disturbing influences. Major attention to optical instruments.

The Optical Industry Directory, [1954.] Optical Publishing Company, Huntington, Long Island, N. Y. Various paging, unbound. $5. 10½ in. Separately paged sections [148p.] include American and foreign manufactures and suppliers, a classified list of products, and "personnel of the industry".

The Physics of the Stratosphere, by R. M. Goody. 1954. Cambridge Univ. Press, Bentley House, London N.W.1, London, England. 187p. $5. 8½ in. Concerned with physics of the atmosphere from above the weather —forming layers to the base of the ionosphere. Discusses temperature and chemical composition, the problems of ozone, winds, turbulence, and thermal equilibrium. Deals with equipment, experimental methods and results, and emphasizes the difficulties of interpretation.

Standard Samples and Reference Standards Issued by the National Bureau of Standards. 1954. U. S. Government Printing Office, Washing 25, D.C. 23p., unbound. 25c. 10 in. (Circular 552). Lists more than five hundred standard samples of ores, metals, ceramics, chemicals and reference standards.

Textbook of Physics, edited by R. Kronig. 1954. Interscience Publishers, New York 1, N. Y. 855p. $10. 9½ in. Translation of a comprehensive work written by a group of Dutch scientists all actively engaged in physical research. About one hundred pages deal with electrical and optical instruments.

Elements of Physics for Students of Science and Engineering, by George Shortley and Dudley Williams. Ed. 2. 1955. Prentice-Hall, 70 Fifth Ave., New York, N. Y. 880 + xviiip. $10. 9¼ in. Gives some attention to "modern" physics. Introduces calculus sparingly on the assumption that the student will be studying it at the same time.

Electronics in Business; a Descriptive Reference Guide, edited by Herbert F. Klingman. 1955. Controllership Foundation, New York 16, N. Y. 176p. $2; members, $1.50. 9 in. Second edition of "Business Applications of Electronic Machines." A bibliography with valuable annotations but no adequate approach by subject. Articles in periodicals are arranged merely under the title of the periodical. Has a separate list of books, and a list of "Pamphlets, Proceedings, Reports." Includes sections on seminars and training programs, visual presentation, data-processing systems, computer installations and commercial digital computing centers.

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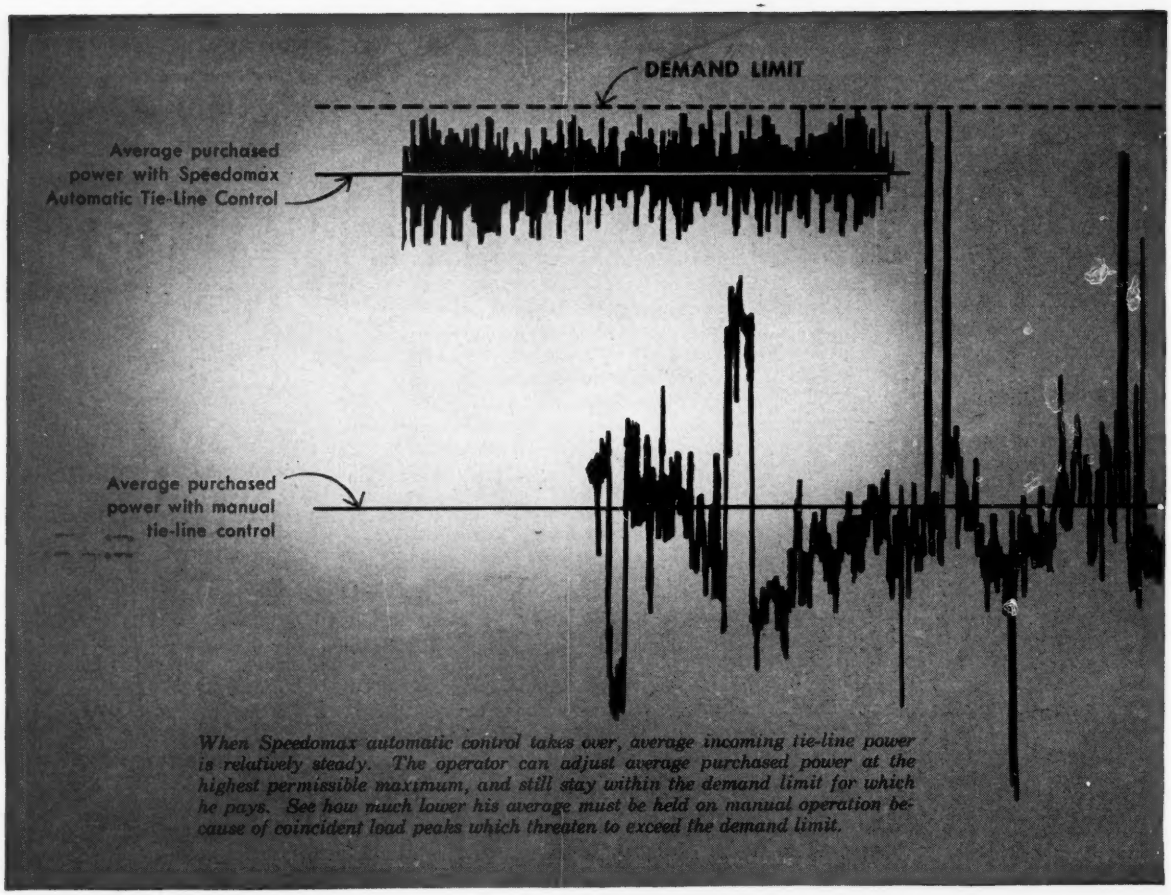
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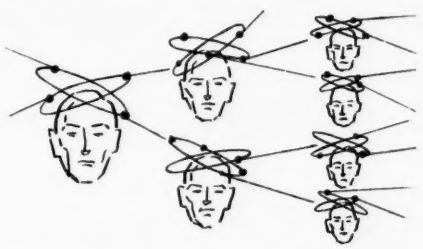
INSTRUMENTS and AUTOMATION

AUTOMATION: The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts.—***M. H. Aronson,*** Editor

Editorial

The SOCIAL REACTOR—About to Explode?

DRAMATICALLY illustrating the speed with which technological developments transform modern society, the first chain reaction—involving the fission of uranium atoms under the bombardment of neutrons—has opened a vast new field of technology in less than two decades. It was not known until 1938 that uranium nuclei would absorb neutrons and then fission, with energy release far greater than that associated with the incident neutrons; yet nuclear reactors will be supplying commercial power to cities in several parts of the world by 1958, and research reactors will be in operation in many modern states by that time. In these few years, a basic scientific discovery has evolved into a vast field of activity with almost infinite applications in practical production, engineering, research, education, etc.



It has been known for a much longer time that technological developments also follow a chain reaction, that each development opens the way to two or more succeeding developments, and that the speed of the reaction depends on the number of scientific workers and their channels of communication. Can it not be true that society also has a "critical" mass at which technological developments will accelerate at an explosive rate? Is it not entirely possible that a direct analogy can be drawn between the "nuclear reactor"—with its fissible fuel, moderator, and critical mass—and the "social reactor"—with its scientific minds, channels of comunication, and numbers of technical workers? And if so, is the social reactor about to explode?

Let us consider the evidence. Every nation is emphasizing technology and technological education. Not only is the world's population accelerating, but the number of technically trained persons is increasing at even faster rate. The action of each practical idea or scientific discovery falling on each of these minds is known to be regenerative—productive of more than one path of further discovery. Indeed, modern channels of communication between trained scientists have made it possible for one idea—the analog of one neutron—to activate a million receptive minds—the analogs of fissible fuel. As the social mass approaches "critical," may we not be on the verge of a technological chain reaction that will make all other chain reactions appear to be but minor manifestations of a cosmic-sized phenomenon?

Civilization and its societies may thus be about to enter a new era, one in which the rate of technological progress exceeds all present ideas, one in which automatic production will—for the first time in the history of man—eliminate forever the war-breeding quests for economic supremacy. The small nations of the world are already emerging as modern states; the larger ones are already finding it necessary to increase production indexes above all anticipated levels. The social reactor is already building up its power level to ratings above all previous designs; the social mass may indeed be approaching "critical."

If such is the case, we stand on the edge of a future of complete abundance—and infinite technological problems. There can be no "labor" problems in a society of abundance, and class conflicts are indeed disappearing within nations of even today's productivity, which productivity will appear absurdly low in but a few years of the present exponential chain reaction of the social reactor. And as the tensions within nations relax, so will those between nations because the competition of ideas, in stark contrast with competition for land, has always

EDITORIAL—CONTINUED

been conducive to the mutual satisfaction of all the competitors.

The fissible material of the social reactor—the element that absorbs one idea to produce two or more—is the technically trained mind. Education thus becomes the real source for the raw fuel—and the teacher becomes the truly key element. The work of one teacher can lead to a thousand trained minds in but a few years—and each mind becomes more raw stuff for the social reactor. Hence the single most efficient way to prime the social reactor is to develop a large and competent group of educators.

This point emphasizes the seriousness of our present situation, wherein our national teaching staff is not only inadequate but declining in adequacy in the face of increasing need. No "practical" person would invest his money at a negative rate of interest—yet most of our nationally-collected funds are being invested in just this way—in military hardware that will be obsolete in just a few years. This is not only a negative rate of interest, but a high one at that. In contrast, every dollar spent on teachers and schools represents positive return, more trained minds, more fuel for our own social reactor.

Another factor associated with chain reactions should be kept in mind. When the critical mass is exceeded, the resultant effect often dwarfs all known experience. We, as a nation, are not adding to the mass of our reactor as fast as are other nations, and whereas the raw fuel for the social reactor takes years to develop, the output shows no such time lag. Thus the first nation to exceed the critical mass of the social reactor will have indeed discovered the key to the future—and others will be hard pressed to meet its achievements. Evidence exists that other nations are more aware of this fact of modern life than are we, and that their social reactors may soon be more advanced than ours.

What can we do to bring our own social reactor to full power output? The answer is a national effort comparable to that which produced the nuclear reactor, but aimed at producing the world's best educational system and teaching staff. Let us find the money for this effort within our military and strategic budget; let us de-emphasize the nuclear reactor in favor of the social reactor; let us cut down on tests and research on atom bombs and divert the effort to tests and research on basic science, engineering, and medicine; let us slash military expenditures deeply and devote the money to a nation-wide education program, to schools, laboratories, and teachers.

This is a program that would bring our own social reactor to a power level above that of the nuclear reactor—a program which, in contrast with our present course, would tend to prevent the social reactor from being destroyed by the nuclear reactor. And whereas the fallout of the latter will destroy the bone marrow in your children's children, the fallout of the former will assure them a full life of individual satisfaction and happiness, and will nourish all the arts and humanities.

This is the glorious promise of technology and automation. But we are not moving in this direction today.

—Milton Aronson

ARE WE THINKING TOO SMALL?

WHEN I was at the Naval Air Missile Test Center I argued for two years for some twenty kilobucks' worth of computing equipment for the Simulation Laboratory. I had to justify this request to everyone from my boss to the Commander of the base—several times.

This had little or nothing to do with the fact that I am no longer at NAMTC. Such small thinking—such short-sighted economy—is the rule rather than the exception. The simple fact is that too many of those who are responsible for the allocation of funds just *don't realize the value of computers!*

True, a computer is only a tool. But computers are powerful tools.

They enable a good engineer to accomplish the seemingly impossible.

They enable mediocre engineers to play their hunches and come up with superior results.

And they even allow bad engineers to make their mistakes quickly, economically—and safely.

We all realize that we have a prodigious scientific and engineering race to win if we are to remain the world's strongest nation. We also know that we are way behind other nations in the number of scientifically trained personnel our schools are turning out. Therefore we must make those people we do have as effective as possible.

There are only two ways to improve the quality and quantity of the work of a given scientific or engineering group: You can hire more and better people; or you can give the ones you have better tools. In practice, you have no choice. You can't get more and better engineers today. Fortunately you *do* have powerful computers. Take advantage of that fact! So—

If you are not furnishing your available scientists and engineers with all of the best tools which they can use, including computers, you are thinking too small!

—John McLeod, Jr.

Third Computer Clinic

The First Computer Clinic (held in conjunction with the First International Automation Exposition, N. Y., 1954) had six principals—Austin, Goodyear, Electronic Associates, Bendix, IBM, and Remington-Rand—and attracted a registration of 202 from all parts of the world. It also led to the highly popular *First Computer Handbook*.

The Second Computer Clinic (Second Automation Exposition Chicago, 1955) registered 392 men who were indoctrinated on the equipments of 9 principals—Austin, Goodyear, Electronic Associates, Bendix and IBM—plus Librascope, Berkeley-Beckman, Clevite-Brush, and Teleregister. The *Second Computer Handbook*, a real powerhouse, will be available shortly and will be sent to all registrants.

The Third Computer Clinic is now being organized, and will have the following principals:

Analog Computer Clinic

Austin Company (special-purpose)
Berkeley Div., Beckman Instruments, Inc.
Electronic Associates, Inc.
Goodyear Aircraft Corp.
Reeves Instrument Corp.
Wang Laboratories

Digital Computer Clinic

Austin Company (special-purpose)
Bendix Aviation, Computer Div.
Computer Control Company
EECO Production Company
Librascope, Inc.
Philco Corp.
Potter Instrument Company
Remington Rand Div., Sperry Rand Corp.
Wang Laboratories

Data Handlers and Office Automation Clinic

Commercial Controls Corp.
Potter Instrument Company
Remington Rand Div., Sperry Rand Corp.
The Teleregister Corp.
Underwood Corp.

It will be held in conjunction with the Third International Automation Exposition, New York City, Nov. 26-30. Advance registration is required—a form will be found on page 1343.

Dear D.R.*:

Maybe you will find time for the important things in this issue between dips in the ocean or naps (or nips) in the hammock if we point them out for you. Hope so, anyway.

Be sure to read the concluding portion of the article on Analog-Digital Converters this month because it winds up this subject in grand manner. In the past two months you learned about the 3 basic conversion techniques (spatial, sweep time, and voltage feedback), and reviewed the available converters using coded discs, inductive techniques, and gears and cams for digital readout. This month the subject is concluded with a review of all-electronic high-speed converters, the peak of the art today. Incidentally, you get "information theory" in your digital automation chapter next month.

The second article in your issue is another really important one—because it shows how a simple everyday problem like scheduling a rolling-mill operation is a "natural" for a computer. Problems like these dispel the mystery from computers, and show how important a quick solution to your everyday problems can be.

Chet Beard covers solenoid and motor valve actuators for you this month. He uses the word "motor" in the sense recommended by The Fluid Controls Institute—that is, implying rotary motion. Electric and gas motors are included. We think you will like his treatment of solenoid actuators also.

Tom Land flew in from England to deliver his paper "Recent British Developments in Suction Pyrometry" at the Pittsburgh Section ISA Conference on Instrumentation for the Iron and Steel Industry. You will find this important original work on pages 1314-1320.

Alvin Kaufman's previous article on accelerometer calibration in *I&A* aroused a lot of interest. So this month we bring you his "Accelerometer Calibration by Ballistic Pendulum." When you are through with this you will really know when and how to use this basic technique.

"Remote Tank Gaging" by H. Dickinson is another interesting article that tells (1) how digital techniques have been put to work to measure tank level, (2) how to select between analog and digital type systems, and (3) how to troubleshoot field-wiring installation in both analog and digital systems. That's a lot of good practical stuff for one article.

Nathan Brewer of Fischer & Porter Company delivered a talk to the Recorder-Controller Section of SAMA, Hershey, Pa., on May 8. We found some important and provocative ideas therein, so we abstracted his talk for you—on pages 1328-1329.

As you can see, this is a good issue this month. Hope it finds you well and happy.

Cordially,
Milt and The Editors

*Dear Reader

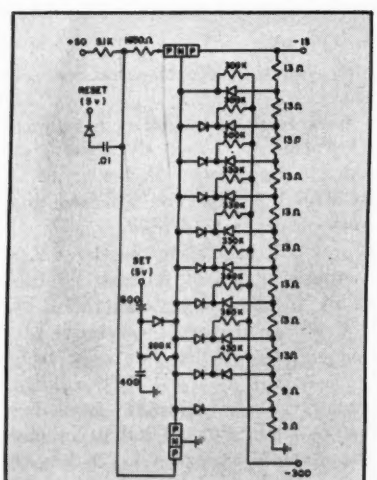
putting IDEAS *to work—research at* IBM

- **Multi-Stable Work Horse: By employing a non-linear load, new circuit permits two transistors to do the work of ten. IBM Bulletin No. 200.**
- **Self-Complementary: New Gas Tube Counter subtracts by adding. IBM Bulletin No. 201.**
- **The Soft Touch: Ultrasonic cutting at IBM permits devices to be cut from hard, brittle materials within 0.0002″.**

For bulletins, write to Dept. IA-7, IBM, 590 Madison Ave., N. Y. 22, N. Y.

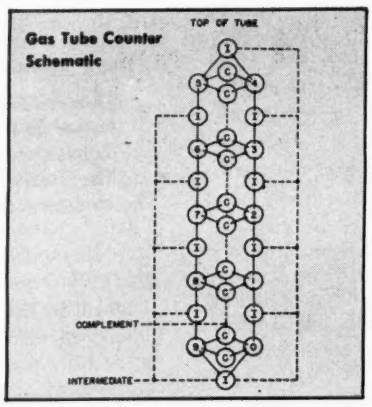
Multi-Stable Work Horse

As the size and complexity of IBM products increase, we are faced with growing numbers of components—which means increased cost. As part of our continuous search for improvement and ways to reduce the number of components, Robert Henle, one of our Transistor Circuit Research people, undertook to get more work out of a given number of transistors. The result is a two-transistor, multi-stable circuit employing feedback controlled by a non-linear load. Junction transistors are naturally suited to this new kind of circuit.



10 Stable State Circuit

A full report on this new idea from IBM contains eight full-page circuit diagrams in addition to mathematical analyses of the operation of the circuit. Write for your copy of IBM Bulletin No. 200.



Gas Tube Counter Schematic

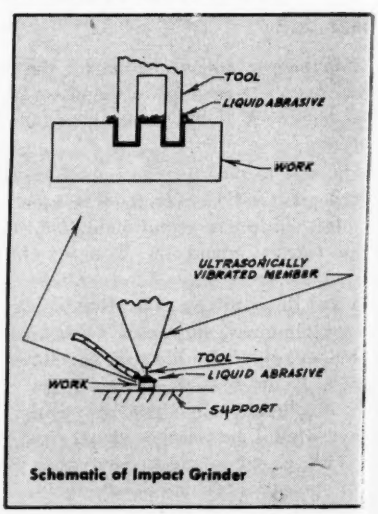
Self-Complementary

Accounting machines these days must be able to do everything—even make decisions. In order to get a machine to do more in a day's time with little or no increase in operating cost, IBM Component Research people studied the idea of using a multi-cathode gas tube. It's good news that they came up with an attractive approach, which Robert Koehler, of our Device Development Group, then reduced to practice; it operates faster than its electro-mechanical predecessor and, furthermore, with simple circuitry, can subtract by adding. It can read out in true number form both positive and negative balances. This is possible because a number stored in the tube may be transposed to its 9's complement (i.e., value subtracted from nine) by a single electrical pulse.

If you'd like more information on the basic principle, physical arrangement of parts, and typical problems solved, write for IBM Bulletin No. 201. If you are fascinated by the theory of numbers, we recommend this Bulletin.

The Soft Touch

In some of our studies of new components, at the IBM Research Laboratories at Poughkeepsie, it is necessary to make many different, small and intricately shaped parts from brittle materials. Following the conventional approach, each of these parts would require laborious and costly machining and fabrication. We turned to ultrasonic cutting; with this tool we can make any shape or size component in approximately a minute—with an accuracy five times greater than previously possible! The ultrasonic cutter has helped us progress faster in our development of new devices. RESEARCH at IBM means IDEAS at work.



Schematic of Impact Grinder

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IBM INTERNATIONAL BUSINESS MACHINES CORPORATION

High-Speed Digital Conversion

Where high-speed analog-to-digital conversion is required, electronic techniques are used. Here is a survey of available equipment for high-speed data logging and digital conversion.

ALL-ELECTRONIC DATA LOGGERS
- Consolidated Electrodynamics (sweep time)
- Kybernetes (sweep time)
- Metrotype (voltage comparison)
- Non-Linear Systems (voltage comparison)

ALL-ELECTRONIC HIGH-SPEED CONVERTERS
- Epsco (voltage comparison)
- Radiation, Inc. (voltage comparison)
- J. B. Rea (voltage comparison)
- Rocketdyne (voltage comparison; also sweep time)

MARTIN L. KLEIN
FRANK K. WILLIAMS
HARRY C. MORGAN

Rocketdyne Div.,
North American Aviation, Inc.

Consolidated Electrodynamics Corporation

CEC, like many other companies, offers analog-digital converters of several types. Their "SADIC" converters for data logging, which use the principle of a self-balancing Thomson-Varley potentiometer having discrete digital balance positions, are slow-speed converters with a speed of conversion of about 1 per second. However, CEC "MilliSADIC" systems (Fig. 9-21) are high-speed all-electronic converters using the time-base or sweep-time principle.

The MilliSADIC principle is the standard sweep-time principle in which the time for a linearly decreasing sawtooth sweep voltage to change from a reference level to the level of the analog signal is counted as a number of pulses. Up to 1500 samples per second may be taken with this converter; the resolution is 1 part in 1000, and the output consists of three binary-coded decimal digits. The converter is but one drawer of the MilliSADIC system shown in Fig. 9-21,B. Such MilliSADIC systems are assembled from building-block components to fill the needs of the individual application.

The MilliSADIC converter has a full-scale input of 99.9 volts and full-scale output is 999 pulses. Thus each pulse corresponds to a 100-mv increment of input signal. Full-scale accuracy of conversion is better than 0.1%.

Although the converter requires 99.9 volts input, the basic input to the system is 0.5 volt, and the system specifications given here include those of the input amplifier. For example, the system will accept up to 100 channels of 0.5-v signals and digitize all channels at a rate of 10 samples per second at a system accuracy of ±0.5% of full scale.

The time required to sample the input voltage and produce a proportional train of pulses is 500 usec; maximum sample repetition rate is 1500 per second on a single-channel basis.

The amplifier (required for low-level signals) has stability, linearity and accuracy better than ±0.1% up to 500 cps.

The output of the MilliSADIC converter is a pulse train, which is translated into digital code for recording by a 3-decade *Counter*. The resultant digital data are transferred to temporary storage and then to magnetic tape by means of a blocking oscillator output.

The *Time Register* provides means for accumulating and storing digital time information (6 digits), which

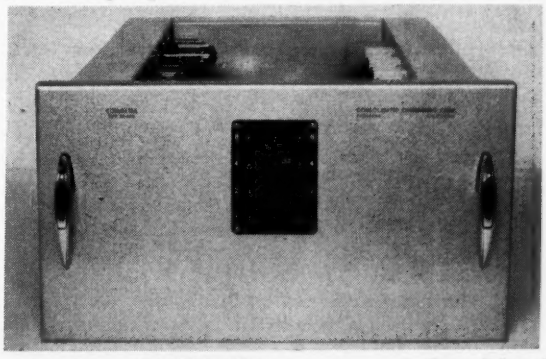
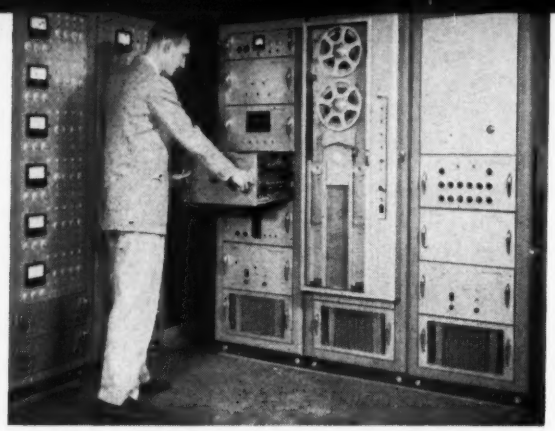


Fig. 9-21. "MilliSADIC" converters of Consolidated Electrodynamics Corporation use the sweep-time principle for conversion of the analog signal into digital form. Up to 1500 samples per second can be taken.



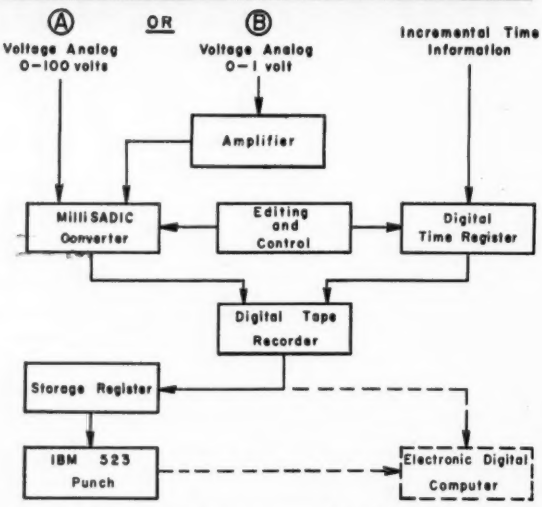


Fig. 9-21,B. Elements in a complete MilliSADIC data-reduction system.

also can be transferred to tape by blocking oscillator output.

High-speed commutation is available for rapid switching between input channels.

The decimal digit output from the Counter-Register and Time Register is a time series of pulses on magnetic tape. The information can be changed into time parallel by use of a magnetic drum, from which the data can be taken in parallel form for use with an IBM 523 punch, etc.

The digital tape can be played back at a slower rate (approximately 10 samples per second) into a paper tape punch or into the Storage-Register to generate IBM cards by the IBM 523. Cards can be generated at a rate of 75 cards per minute with 20 data samples, 6 digits of timing information, and 14 fixed constants.

The Kybernetes Corporation

The various inputs (analog voltages) to be logged are brought into the Kybernetes Logger (Fig. 9-22) via a cross-bar switch, which has an expected maintenance-free life of 200,000,000 operations (6.3 years operating at one point per second).

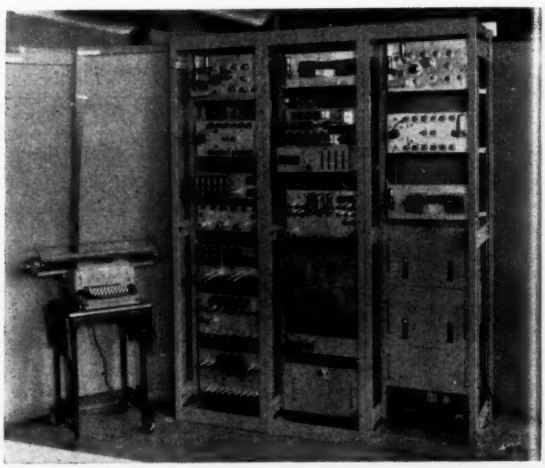
The programmer unit determines the sequence of logging, allowing the cross-bar switch to be programmed at random. The variable selected is first amplified by a chopper-type amplifier, essentially an electronic self-balancing potentiometer. The incorporation of nonlinear elements has made it possible to achieve a speed of response not ordinarily found in contact-modulated-type amplifiers. Noise level is less than 5 microvolts peak to peak, and long-term drift is less than 30 microvolts.

The amplified signal constitutes a voltage which is proportional to the measured variable; this is compared with a linear or characterized sweep voltage produced by a sweep generator. The gate circuit shown opens at the instant the sweep starts and closes at the instant that the sweep voltage equals the amplitude of the unknown variable. The precision of the gating accuracy is one part in fifty thousand and the sweep functions are accurate to 0.05%.

The interval during which the gate is open, which is proportional to the magnitude of the unknown variable, is measured by storing the counts from the crystal-controlled oscillator in the digital counter storage unit. This count is first divided electronically for scaling purposes and then is stored in units, tens, hundreds, etc. No encoding or decoding components are required because conversion is made directly to digital notation which is then directly read by an Underwood electric typewriter.

One feature is linearization of the inputs via sweep characterization. Square-root extraction is performed by use of a parabolic sweep. Thermocouple curves are also compensated throughout their ranges. Alarm functions are incorporated, and a separate Clary printer can be used to record off-normal variables.

For checking, a standard voltage equivalent to a printed



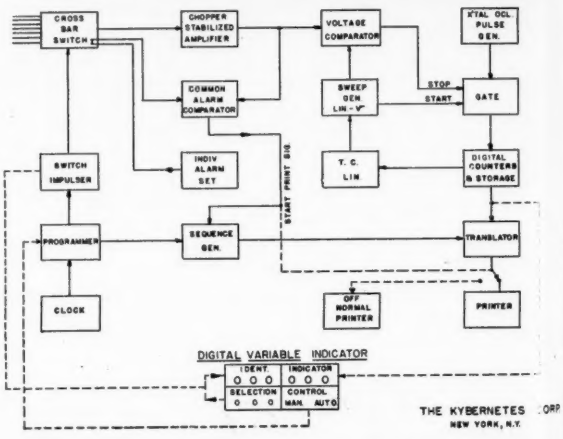


Fig. 9-22. The Kybernetes automatic data logger uses the sweep-time principle for conversion of process variables into digital form. Alarms and visual readout are also provided. Cabinet doors have been removed so chassis can be seen.

number of 800 is switched into the logger at the beginning of each logging cycle. A printed result of 801 would represent an error of 1 part in 800. Over-all accuracy is ± 0.2% of full scale.

The Digital Variable Indicator (DVI) provides for a 3-digit or 4-digit display on the remote console or panel of any input as selected by push-buttons.

Metrotype Corporation

The basic Metrotype analog-digital conversion system (Fig. 9-23) is designed to accept low-level input signals, as from thermocouples. It translates them into digital readings which can be either printed out, observed on a visual indicating meter, or displayed on digit lamps. The input may be from a single sensor device, or may be automatically or manually selected from a group of sensing elements in any given order by a programmer.

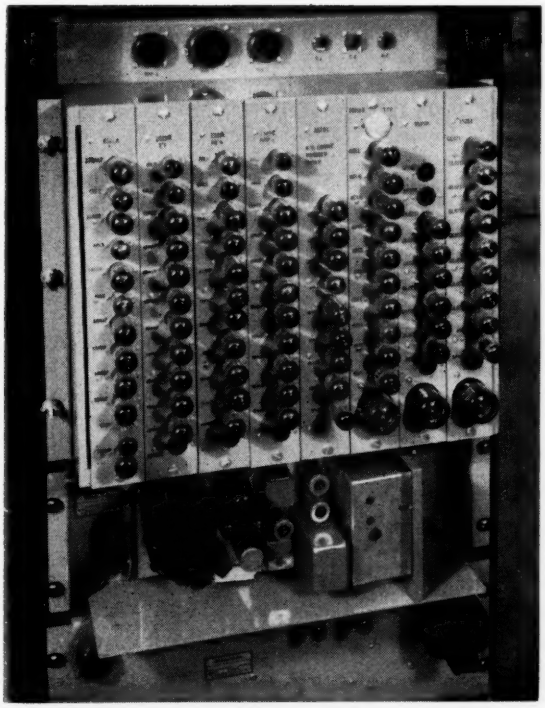
An oscillator is turned on at the instant that the input is applied to the converter. For the purposes of this description, 0-1000 pulses are shown as maximum count. These pulses go to the *unit* counter, and for each ten pulses received a pulse is sent to the *tens* counter; for each 100 pulses received a pulse is sent to the *hundreds* counter.

Each counter operates in the following manner: Each pulse received causes a combination of tubes to conduct, the conducting tubes operate electronic switches. A regulated voltage passes thru the operated switch into a precision resistor, thus producing a current. The precision resistors are in a ratio of 1:2:2:4 so that each pulse gives an exact increment of *additional* current.

This current is passed thru the feedback resistors, as shown. Each pulse on the units counter develops 2.5 mv in the feedback circuit, while each pulse on the tens and hundreds counter develops 25 mv and 250 mv respectively. The feedback voltages thus builds up in a step fashion, each step being equal to 2.5 mv.

The inputs to the system are normally amplified to a 2.5 v signal which appears as one input to a null balance detector. When the counter pulses generate a voltage equal to the input signal, a stop pulse is sent to the electronic oscillator control, shutting off the oscillator. The count in the tubes is then coded, or directly operates a printer or other digital device.

Features include automatic standardization, any number of digits as required, output to Teletype or electric typewriter or any desired printer, no slidewires, standard speed of 0.1 second per point, linearization or characterization of input curves as desired, accuracy of ± ½% of full scale.



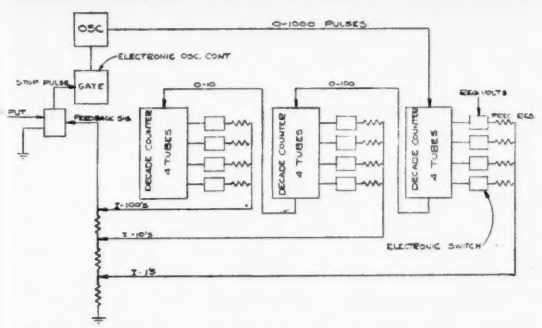


Fig. 9-23. Metrotype data logger uses voltage-comparison technique for conversion of process variables into digital form.

Non-Linear Systems, Inc.

The NLS 311 analog-to-digital converter of Non-Linear Systems (Fig. 9-24) measures d-c voltages with resolution of 12½ microvolts by means of voltage-comparison technique. The unknown voltage is compared with standard reference voltage through the use of 12 digital scanning units; a thirteenth indicates polarity.

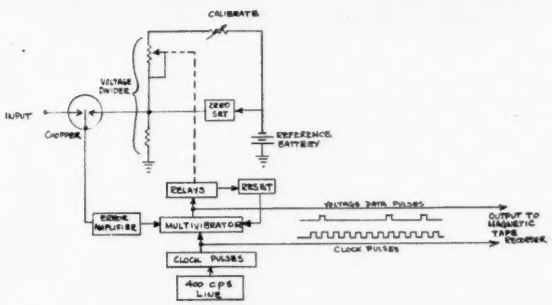


Fig. 9-24. The NLS 311 digital converter of Non-Linear Systems uses voltage-comparison technique for digital conversion.

The counting rate is 20 conversions per second. At the end of each measurement the converter provides a relay closure that triggers a recorder. An accessory coded readout also can be connected to the converter to display each measurement visually up to a full scale of 999 digits.

The converter is essentially a self-balancing potentiometer. A voltage equal and opposite to the input is set up, using a relay-operated voltage divider and reference battery. Each relay is operated in succession once per scan, the error amplifier deciding whether each relay should remain open or closed to attain a balance. The state of each relay determines whether a pulse should appear on the voltage data pulse line output at any time. Thus, the output is "pulse or no pulse" (depending on relay position and, therefore, on voltage divider setting) as a function of time.

Its major application is to convert signals from low level d-c transducers (thermocouples, strain gages, etc.) into binary-coded decimal form for high-speed magnetic-tape recording. Originally designed for aircraft flight test work, it operates from 400-cps 28-volt d-c power, and withstands aircraft temperature, humidity, shock and vibration environments. Its accuracy is $\pm 0.1\%$ of full scale range (12.5 microvolts to 12.5 millivolts).

HIGH-SPEED ALL-ELECTRONIC ANALOG-DIGITAL CONVERTERS

At present there are several high-speed (10,000 to 100,000 conversions per second) all-electronic analog-digital converters in operation. Units for up to 200,000 conversions per second are said to be in the design stage. Most are based on the feedback-encoding technique of supplying standard voltages according to a fixed logical program, as described previously. One unit is a time-base (sweep) converter which makes use of 20-Mc flip-flops.

The following converters show the state of the high-speed conversion art:

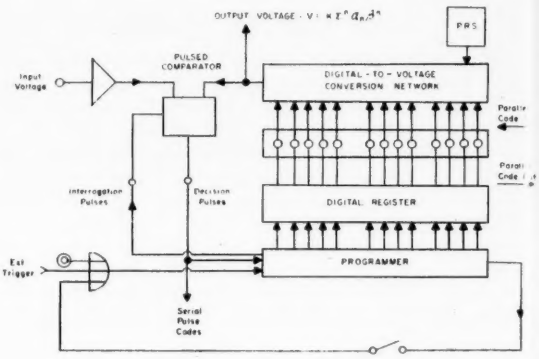
Epsco (voltage comparison)
Radiation, Inc. (voltage comparison)
J. B. Rea (voltage comparison)
Rocketdyne (voltage comparison and sweep time)

Epsco, Inc.

Voltage comparison, or voltage feedback, technique is used in the "DATRAC" Converters offered by Epsco, Incorporated. The converter (Fig. 9-25) comprises a digital storage register, a digital-to-voltage conversion network, a pulse comparator, and a programming unit. Digitalization is carried out by a series of successive approximations and decisions. The input voltage is compared first with the maximum binary voltage from the conversion network. If the voltage of the former is less than that of the latter, the most significant digit in the digital register is cleared and the next most significant digit is switched in.

The process of switching in the next most significant digit, while a decision is made as to whether the previous digits should be kept, is continued until appropriate decisions have been made for the entire code. Therefore, with binary decisions being made every 2 microseconds, a complete digitalization into a 10-place binary code is made in 20 microseconds, while digitalization into an equivalent binary coded decimal notation is made in 24 microseconds.

Two types of high-speed converters are offered—the Model A and the Model B. The Model B makes up to 50,000 independent conversions per second; as it takes two microseconds to make a binary decision, it takes 20 microseconds to convert into a 10-place binary, or 22 microseconds to convert into an 11-place binary code. The Model A, on the other hand, is a servo-type converter, consisting of a forward-backward counter which is servoed to the proper code. This unit's yield is 200,000 new codes per second, but these codes are not independent.



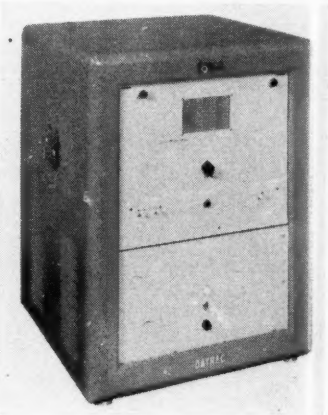
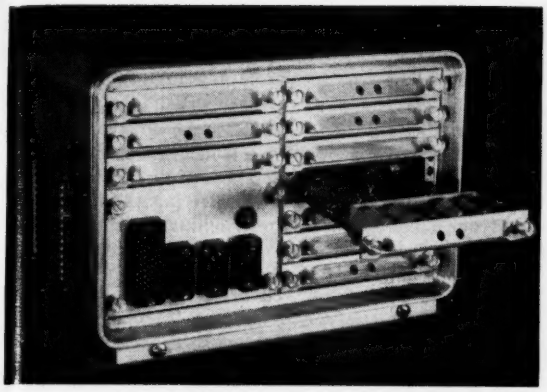


Fig. 9-25. DATRAC converters offered by Epsco, Incorporated, use voltage-comparison technique for high-speed conversion.

Radiation, Inc.

The ADAR analog-to-digital converter offered by Radiation, Inc. (Fig. 9-26) uses the voltage-feedback principle to provide 24,000 8-bit binary code groups per second. It features small size and light weight (8 pounds), solid-state components and all-electronic circuitry.

This coder employs the "half-split" sampling technique wherein the analog input samples are sequentially compared against precision binary-weighted currents that are generated within the coder. The first comparison is made at 50% of full scale. If the input signal is less than 50% of full scale, the coder generates a "no" bit of code and the second comparison is made at the 25% level. This process continues for eight comparison levels and the eight decisions comprise the 8-bit binary code, as shown. Accuracy is one part in 256 ($\pm 0.4\%$ of full scale).



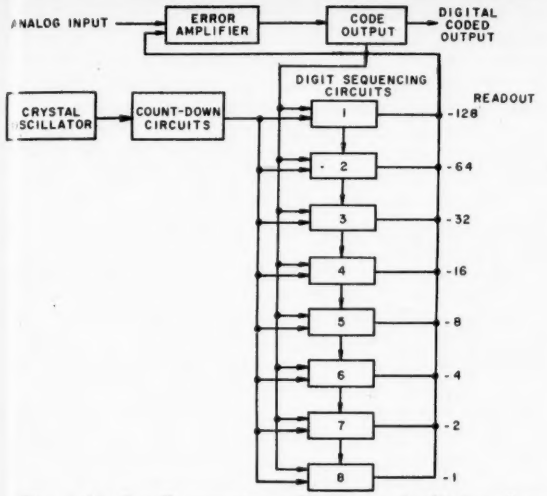
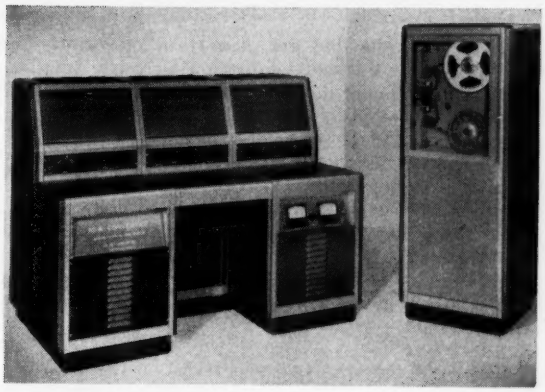


Fig. 9-26. Small converter offered by Radiation, Inc., uses voltage-feedback technique to provide 24,000 8-bit binary code groups per second.



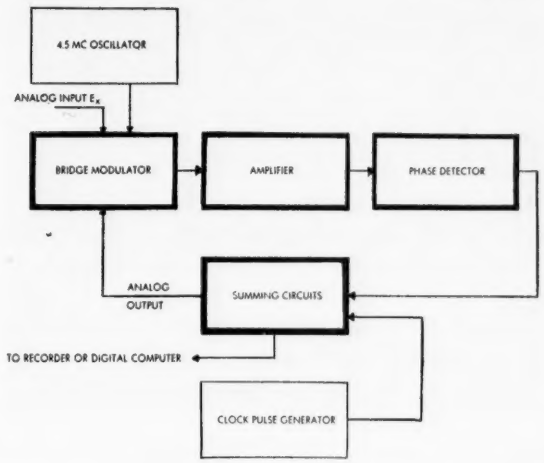


Fig. 9-27. Rea-Converter of the J. B. Rea Company uses voltage-feedback technique for high-speed conversion at rates up to 100,000/sec.

J. B. Rea Co., Inc.

One of the feedback-encoding converters presently available and in operation is the Rea-Converter of J. B. Rea Co. (Fig. 9-27). The four main parts of the converter are the modulator, the amplifier, the phase detector, and the summing circuits. The 4.5-Mc oscillator supplies power to the modulator, and the clock-pulse generator steps the converter through the conversion from an analog input to a digital output.

The bridge modulator compares the input voltage E_X with an analog voltage received from the summing circuits. The output of the modulator has three possible forms: one when E_X is greater than the analog voltage generated by the summing circuits; one when E_X is less than the generated analog voltage and the third, or zero output form, when E_X equals the generated voltage.

The phase detector, like the modulator, can have only one of three states, corresponding to the three states of the modulator. The output of the phase detector is used by the summing circuits to program the analog feedback voltage.

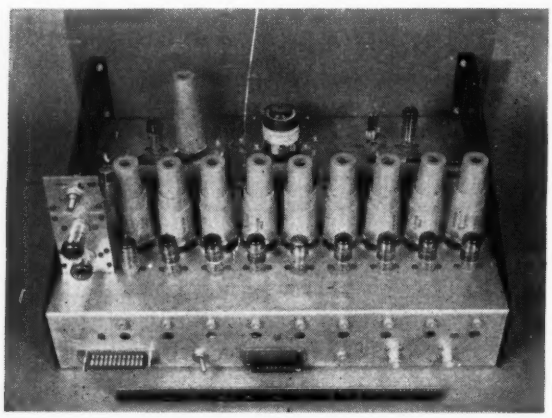
The summing circuits consist of 13 accurate voltage sources, which are added to form a sum. The value of these sources can be chosen to fit any arbitrary scale or range required. The clock pulses turn each of these voltages on in order, and each new voltage is added to the sum of the other voltages present. The voltage turned on by the first clock pulse is the largest and it is compared by the modulator with the input voltage E_X. If E_X is larger than this generated voltage, the phase detector "locks" this voltage on. If E_X is smaller, the phase detector turns this voltage off. The second clock pulse turns on the next largest voltage and adds it to the sum. After the voltages have all been turned on and either removed or locked on by the phase detector, the voltage sum generated is equal to the input voltage E_X.

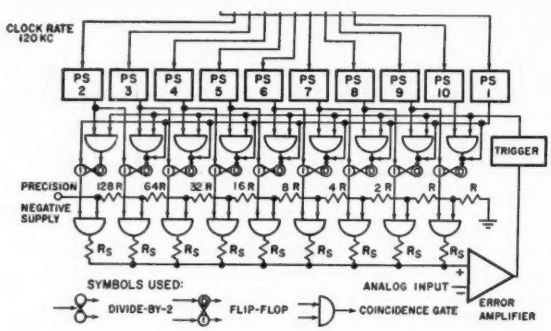
The smallest voltage source is arbitrarily assigned the number one. All other voltage sources are a whole number times larger than the smallest and are assigned that number. These ratios determine the code of the converter and can be made to match any computer code—binary, binary coded decimal, octal, etc. The 13 voltage sources and corresponding assigned numbers will give a ± 1000 scale when using a binary coded decimal, and a higher scale, $\pm 2^{12}$, when using the binary scale. Sampling rate of standard Rea-Converter is 8000 samples/sec; higher clock frequencies give sampling rates up to 100,000/sec with resolution of 1 part in 1000.

Rocketdyne, North American Aviation

Two other units that are already in operation were developed at the Rocketdyne division of North American Aviation, Inc. One of these is a programmed encoder and is part of a complete automatic data-reduction system known as IDIOT* II (to be described in later chapters). This converter, similar to the Rea converter, generates ten highly accurate standard trial voltages, at a rate of 120 kc. The voltages are binary weighted voltages (512 units, 256 units, 128 units, etc.) from a chopper-regulated source which is compared with a standard cell. The logic produces a ten-bit encoding while minimizing the error between the generated binary voltages and the input voltage.

*IDIOT refers to Instrument Laboratory DIgital On Line Transcriber.





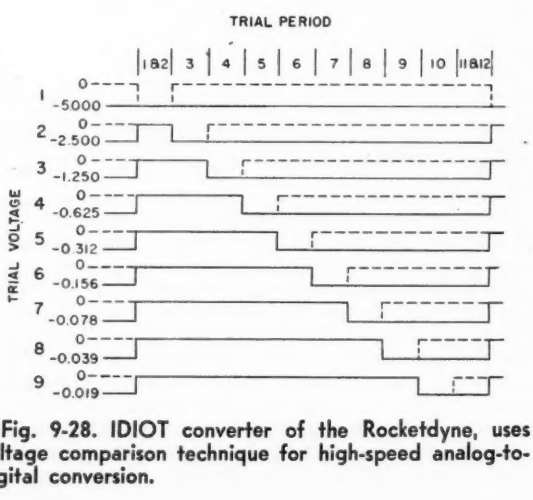


Fig. 9-28. IDIOT converter of the Rocketdyne, uses voltage comparison technique for high-speed analog-to-digital conversion.

The timing diagram of the trial voltages and their magnitudes are shown in Fig. 9-28. The solid lines indicate the state retained if the sum of the trial voltages exceeds the analog voltage: the dotted line shows the resetting of the trial voltage if the trial voltage sum is less than the analog signal.

The convertor shown at the top in Fig. 9-28 is a 9-bit encoding IDIOT II converter. The logic is similar to the 10-bit IDIOT II, except that the driving pulses are derived from a Burroughs beam-switching tube which provides a decade ring output. A ring of twelve is required for the ten-bit IDIOT II.

The logic of the 9-bit converter is executed by the circuit shown at the center in Fig. 9-28. Ten driving pulses are provided by the Burroughs tube. The states to be held are retained or rejected by the flip-flops, which enable or disable the standard voltage gates. These gates switch on the standard binary voltages; the outputs are summed for the error amplifier (which also receives the analog voltage). The largest voltage is tried first, and then successively smaller voltages are added to this.

To follow through a single encoding, a pulse is produced through pulse shaper one (PS1). This sets the left-most flip-flop and resets the others. Having set the flip-flop, the largest binary trial voltage (256 R, which is the sum of 1R+1R+2R—+128R) is enabled and reaches the difference amplifier. If this voltage is less than the analog voltage, the error amplifier does not energize the trigger circuit. The second pulse from the Burroughs tube switches in the second trial voltage (128R) via PS2. If the first trial voltage (256R) had exceeded the analog voltage, and by an amount equal or greater than 1R, a pulse would have been supplied by the trigger to the first coincident gate. The second pulse via PS2 then would have reset the first flip-flop, subtracting the first trial voltage (256R). This sequence of operations proceeds through the entire conversion cycle. The binary coding of the analog input voltage, therefore, is the state of the nine flip-flops which exists after the tenth pulse from the Burroughs tube energizes PS10. This code is then read out into any convenient buffer storage when the flip-flops are reset via "and" gates (not shown).

Such a converter depends on the accuracy of the d-c error amplifier in the circuitry. In this converter a d-c chopper-stabilized type is used, which has a rise time such that the final value of the trial value is reached (within .2%) in seven microseconds. As chopper -stabilized amplifiers tend to react slowly to over-loads, limiting protection in the form of diode clippers is inserted to keep the initial errors (trial periods 1, 2, 3 & 4) from overdriving the amplifier. When the error is small, the limiters are effectively not in the circuit and do not effect its stability.

The 10-bit IDIOT II convertor uses an improved error amplifier and a faster standard-trial-voltage generating network. This convertor is capable of 100,000 complete 10-bit analog-to-digital conversions each second because standard trial voltages can be generated in less than 1 microsecond to an accuracy of 0.1%. Digital-to-analog conversions can be made at a rate above 1 million per second to an accuracy of 0.1%. Even higher accuracies are possible.

The significant difference between the IDIOT Converter and the Rea-Converter is in the error amplifier —the former uses d-c amplification; the latter uses a carrier-type amplifier. Both have relative advantages and disadvantages.

Next month: "Information Theory"

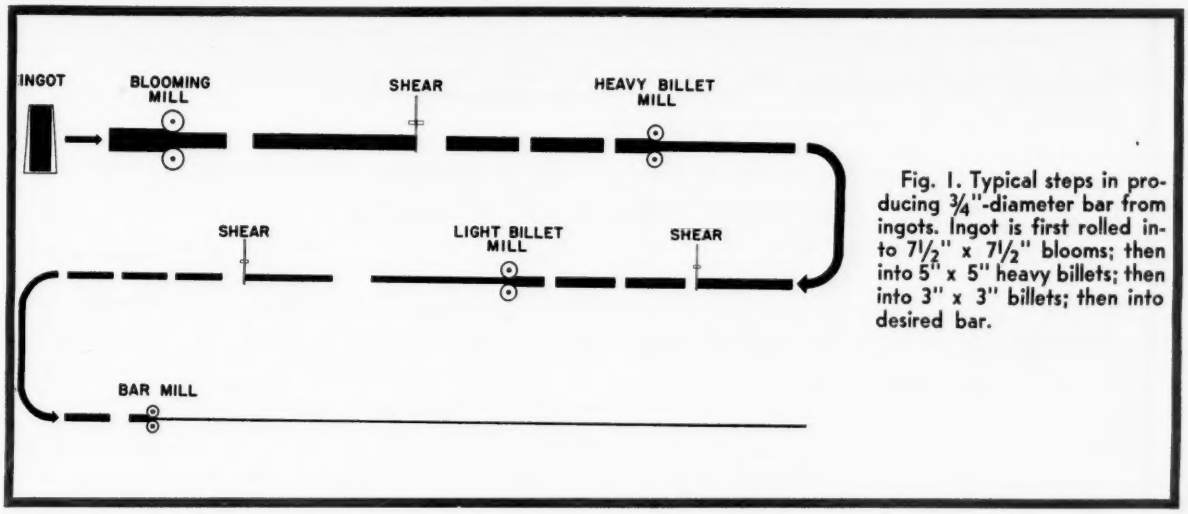


Fig. 1. Typical steps in producing ¾"-diameter bar from ingots. Ingot is first rolled into 7½" x 7½" blooms; then into 5" x 5" heavy billets; then into 3" x 3" billets; then into desired bar.

Computer Control *of a* Rolling Mill Schedule

Problem: Either a short pour or an excessive crop of a 24,000-lb ingot can drop the yield of 90-lb bars by 5%. How best to schedule the rolling operation to minimize waste?

Solution: Use a special-purpose computer to tell you how best to cut each billet after the ingot is cropped.

A. H. KUHNEL
The Austin Company

SPECIAL-purpose computers can be extended beyond the individual machine. They can be applied to an entire sequence of machines that together make up a manufacturing process. We shall illustrate this by considering the well-known process of manufacturing structural steel shapes in a rolling mill. We can do this most readily by considering a simple product such as a ¾"-diameter steel reinforcing bar.

The steps involved in the process of manufacturing steel reinforcing bars (Fig. 1) are:

1. Produce the steel. This is usually done in an open-hearth furnace.
2. Pour the ingots. The size of the ingot usually depends on the capacities of the various mills in the rolling mill.
3. Strip the molds from the ingots.
4. Prepare ingots for rolling in soaking pits.
5. Roll ingots into blooms.
6. Crop blooms and cut to length for large billet mill.
7. Roll into billets of large cross section.
8. Crop and cut to length for small billet mill.
9. Roll into billets of small cross section.
10. Crop and cut to length for bar mill.
11. Roll into finished bars.
12. Cut to length for cooling tables.
13. Cut to final shipping length.

In scheduling an order of reinforcing bars for production, the production department must specify the heat from which the steel is to be taken, specify the size and number of ingots, the size and number of blooms, the size and number of large billets, the size and number of small billets, the cutting lengths of finished bars for the cooling tables, and the final cutting length for shipment. Naturally, in setting up such a schedule, the production department is guided by the capacities and limitations of the equipment in the mill and also by general practice in the mill.

A fairly typical case in the manufacture of ¾"-diameter bars might be to reduce the ingots to 7½" square blooms in the blooming mill, reduce to 5" square billets

Presented at Second Computer Clinic, 2nd International Automation Exposition, Chicago, Ill.

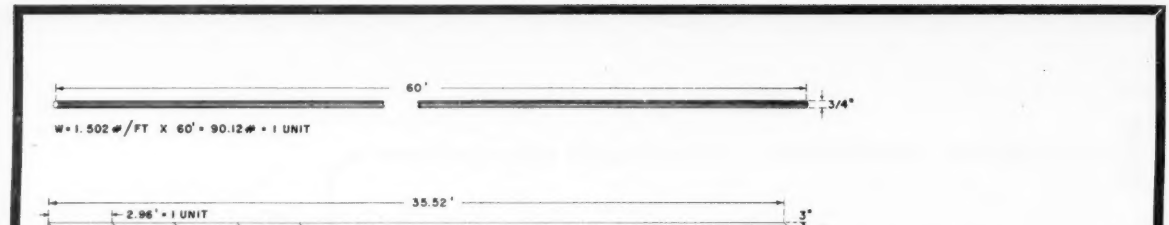


Fig. 2. Optimum lengths of blooms and billets so that final ¾"-diameter-bar wastage is minimized. Note that less than ½ foot (1 unit) of 7½" x 7½" bloom makes one 60' bar.

in a heavy billet mill, then to 3" square billets in a light billet mill, and finally to the ¾" bar in a bar mill, as shown in Fig. 1.

Let us assume that the ingots are limited in gross weight to 24,000 lbs., and that blooms and billets are limited to 40' with the preferred length ranging from 36' to 40'.

Scheduling An Order

Let us now schedule an order for 130,000 feet of ¾" round bar, where the shipping length will be 60' with a tolerance of 10% of random shorts ranging between 30' and 60'. The bars will be rolled from 3" x 3" billets in the bar mill. These billets shall be 36' to 40' long. The billets will be rolled from 5" x 5" billets in a billet mill. Again the 5" x 5" billets shall be 36' to 40' long. The 5" x 5" billets will be rolled from 7½" x 7½" blooms which shall also preferably be 36' to 40' long. The blooms shall be rolled from ingots not exceeding 24,000 lbs gross weight.

Weights and Sizes

The first factors to establish are the exact sizes and weights of ingots and billets so as to minimize waste. The weight per lineal foot of the materials are:

¾" bar — 1.502 lbs/ft
3" x 3" — 30.6 lbs/ft = 20.37' of ¾" bar
5" x 5" — 85.0 lbs/ft = 2.778' of 3" x 3"
7½" x 7½" — 191.25 lbs/ft = 2.25' of 5" x 5"

For a first approximation, we find the required net weight of steel: 130,000' or ¾" round bar at 1.502 lbs/foot = 195,260 lbs. Assume yield is 84%. Then gross weight = 195,260/0.84 = 232,452 lbs.

Therefore, number of ingots = 232,452/24,000 = 10.

As the final shipping length of the ¾" round is 60', the total yield from a 3" x 3" billet should be a multiple of 60'.

720' of ¾" bar = 720/20.37 = 35.346' of 3" x 3". Therefore, cut 3" x 3" billets to 36' length.

The 5" x 5" billet should produce a multiple of 36' of 3" x 3" billets. 108' of 3" x 3" = 108/2.778 = 38.86' of 5" x 5". Therefore, cut 5" x 5" billets to 39' length.

The 7½" x 7½" bloom should produce a multiple of 39' of 5" x 5" billets. 78' or 5" x 5" = 78/2.25 = 34.67' of 7½" x 7½". Therefore, cut 7½" x 7½" to 35' length.

Weight of 35' of 7½" x 7½" = 35 x 191.25 = 6,693.75 lbs.

Weight of 3 pcs. 7½" x 7½" x 35' = 3 x 6,693.75 = 20,081.25 lbs.

Therefore, net weight of ingot = 20,081.25 lbs.

Assume 13% crop.

Gross Weight of Ingot = 20,081.25/0.87 = 23,082 lbs. Therefore, order Ingots of Gross Weight = 23,100 lbs.

Yield of 1 Ingot: 3 Blooms 7½" x 7½" x 35'; 6 Billets 5" x 5" x 39'; 18 Billets 3" x 3" x 36'; 36 Bars ¾" round x 360'; 216 Bars ¾" round x 60' = 12,960'

10 Ingots yield 12,960 x 10 = 129,600' of ¾" round bar; this is 400' short of order.

Assume random shorts will make up balance.

Gross Weight of Steel = 10 x 23,100 = 231,000 lbs.

Net Weight of Product = 130,000 x 1.502 = 195,260 lbs.

Then percent yield = 84.52%

This order then goes to the mill, and if all goes according to plan the order will be filled and the yield will be as calculated.

Sources of Trouble

However, even in the best managed mill, things do not go according to plan. The first difficulty arises in pouring the ingots. The order calls for a gross weight of 23,100 lbs per ingot. This is slightly less than the capacity of the mold. Suppose the mold is filled to capacity. This is 900 lbs more than called for. If the cutting directions are followed in the subsequent operations the order will be readily filled and there will be no trouble.

Suppose, however, that the pour is a few hundred pounds short—500 pounds, to be exact.

An ingot 500 lbs short will weight 22,600 lbs. Assuming an 87% crop, the net weight will be 22,600 x 0.87 = 19,662 lbs. Length of 7½ x 7½ = 19,662/191.25 = 102.8′

After 2 cuts of 35′ have been taken, the last piece will be only 32.8′ long. This bloom will produce 32.8 x 2.25 = 73.8′ of 5″ x 5″. After one 39′ cut has been taken from the 5″ x 5″ section, a piece 34.8′ will be left. This will produce 34.8 x 2.778 = 95.67′ of 3″ x 3″. After two 36′ cuts have been taken from the 3″ x 3″, a piece 23.67′ will be left.

This will be a short that will ordinarily be discarded because it would require special handling to get it into the bar mill, and the time lost in attempt at salvage will make its use uneconomical. The result will be a shortage of 720′ of ¾″ bar from this ingot. Were this to occur in 10 ingots, the shortage would be 7,200′ on the order. The yield would drop from 84.52% to 79.85%.

The situation described is a common occurrence. Shortages result, however, not only from a short pour, but also from excessive crop. The crop of 87% assumed above is typical. The actual crop may be more or less, depending on the condition of the steel as observed by the roller after several passes through the blooming mill. It simply is not possible to control the gross weights and cropped weights of ingots rigidly enough to enable calculations such as the above to be made with any accuracy. As a result, it is not uncommon to provide for processing losses of 5% to 10% more than ideal in order to insure against shortages in final product.

Computer Overcomes Trouble

This difficulty results from the fact that it is impossible to determine in advance precisely how many pounds of good steel will be obtained from an ingot. It is no problem to determine the size or weight of the bloom after it has been cropped. However, at this stage of the manufacturing process time does not permit a re-scheduling of subsequent operations. A computer given as its input either the size or the weight of the bloom, and also the dimensions of the alternate product, can perform the necessary calculations in a matter of seconds. Therefore, such a computer can be employed to schedule all of the operations in the process in such a manner that there will be virtually no waste of good material.

The first requirement is to determine the net product in the ingot. This can be determined either by weight or by volume. If volume is used, allowance must be made for expansion of the metal due to temperature.

Essentially there are two aspects to the problem: (1) We wish to obtain as many as possible pieces of ¾″ round by 60′ from the cropped 7½″ x 7½″ bloom. (2) To reduce handling through the several stages of the operation it is desirable to make each bloom, billet, or bar as long as possible, but not so long as to exceed the handling capacities of the various transfer tables, feed tables, and run-out tables. This limit we have assumed at 40′ except for the final bar, which is limited to 400′ by the length of the cooling bed.

By approximation, the problem can rapidly be reduced.

First we calculate the lengths of the various sections that produce 1 unit from their known unit weights, as follows:

60′ of ¾″ round at 1.502 lbs/ft = 90.12 lbs = 1 Unit.

90.12/30.4* = 2.96′ of 3″ x 3″ = 1 Unit.

90.12/85.0* = 1.0656′ of 5″ x 5″ = 1 Unit.

90.12/191.7* = 0.4736′ of 7½″ x 7½″ = 1 Unit.

Based on these units, it can be shown (Fig. 2) that an economic solution is to make 18 billets of 3″ x 3″ x 35.52′ and to make 1 extra of 39.871′; 5 billets of 5″ x 5″ x 35.3613′ and 1 extra of 36.9273′; 2 blooms of 34.101′ and 1 extra at 34.797′.

These will yield 217 pieces of 60′ bar and have scrap of only 0.47 piece, or 28.9′ of ¾″ round bar.

A computer to handle the relatively simple arithmetic can readily be provided. Although the problem is essentially digital in nature, the required accuracy does not preclude the use of an analog computer.

Inputs required are the unit weights of the various intermediate and end product, the piece length of the end product, and the limiting lengths of the intermediate sections. The length of each cropped bloom can be manually measured and inserted into the computer, or it can be automatically measured and inserted.

The computer will then produce the cutting lengths at each step. These can be indicated on indicator boards or, if the mills are equipped for automatic cutting length control, stored and sequenced out as required.

Note that in the example given there was 28.9′ of scrap as compared with 13,220′ of product of the desired unit length. This is practically the worst result that it is possible to get. Had the residue been 30′ instead of 28.9′ it would have been a saleable short and there would have been no scrap.

The question may well arise as to what will happen when there are errors in cutting to the calculated length. Of course, the computer has no control over this other than the provision made to add a tolerance of 0.5% to allow for cutting errors. This was done by adding this amount to the actual unit weights of the several sections. Had cutting been exact through-out, this amount would be found added to the length of the last piece of each section. If a slight excess is added at each cut to guard against short cuts, then this 0.5% will be fairly uniformly distributed. Actually, in the example given, this allowance amounted to 66 feet of ¾″ round in 13,220 feet.

*adjusted to allow for cutting tolerances.

And cursed be he who slaves away,
Who drives himself both night and day,
And never stops at all to play:
For maybe he has never learned to live!

Since all of us have mortal goals,
And all of us immortal souls,
Can we strengthen self-controls
By living lives a bit more positive? —*Clifford B. Haughton, Jr.*

Solenoid and Motor

Both solenoids and motors are basic valve actuators. Solenoids are used extensively either as actuators or as pilot valves for other valve actuators; motors can be either electric or gas powered. New techniques for electric-motor actuators include over-volting and stem-force sensing.

MODERN automation systems use pneumatic, hydraulic, mechanical, electrical and electronic control elements. All of these types of valve actuators are in use.

Pneumatic actuators have been and still are the most common. However, electric, electropneumatic, and electrohydraulic actuators are becoming increasingly important where all-electric or -electronic systems are being installed. Pneumatic actuators have been described previously; this chapter describes electric (solenoid and motor), gas motor, and hydraulic motor actuators, and combinations thereof, with emphasis on electric actuators. (The word "motor" implies a device whose output is rotary motion.)

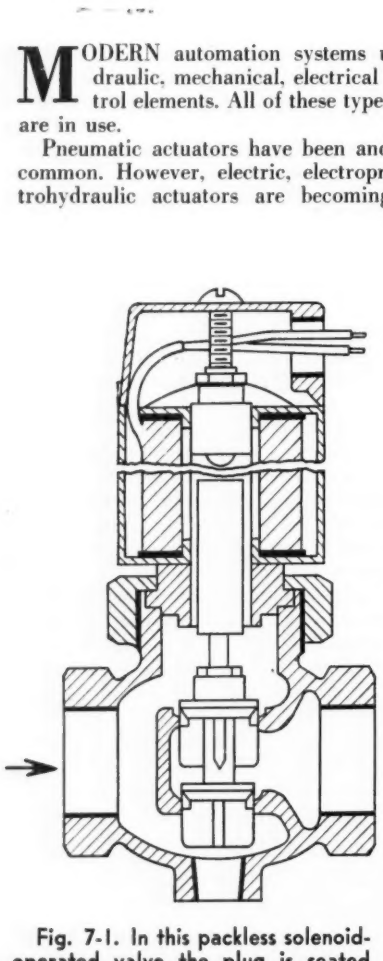


Fig. 7-1. In this packless solenoid-operated valve the plug is seated when the core is not energized owing to the weight of the solenoid core and inner valve, and also by the flow which enters over the larger seat and under the smaller when flow enters at left.

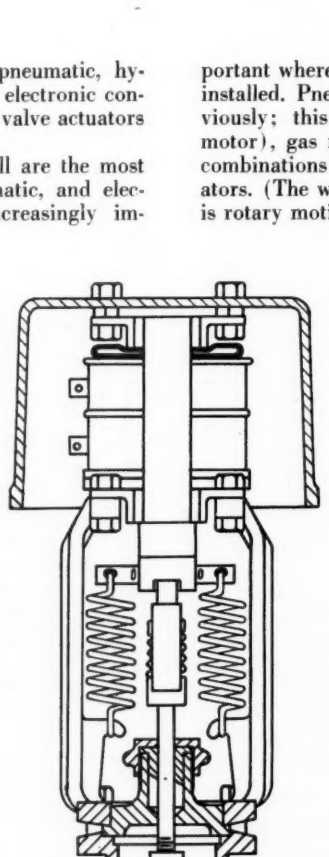


Fig. 7-2. Springs help overcome hysteresis in this packed-type solenoid-operated valve.

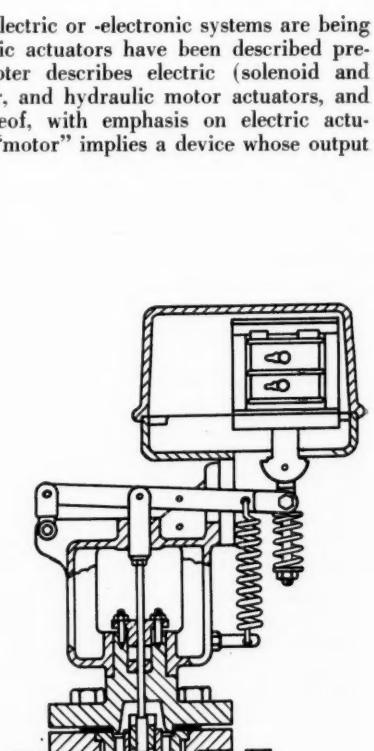


Fig. 7-3. Levers can be used to multiply the force of the solenoid, or to reverse the action of the actuator.

Actuators

C. S. BEARD

Foster Engineering Company

Solenoid Valves

Use of a solenoid (a soft iron core that can move within the field set up by a coil surrounding the core) is a common means of opening or closing a valve. The force of the solenoid is used to pull the valve plug—either to open a normally closed valve or to close a normally open valve.

Fig. 7-1 shows a packless valve whose plug drops to a seating position under the weight of core and valve plug, and also because of the flow which enters over the larger of the seats and under the smaller. Hence the resultant force due to flow and static pressure is downward.

Springs assist in overcoming hysteresis in the packed type shown in Fig. 7-2.

Reverse action (to open when de-energized) can be obtained by reversing the valve plug, but is usually accomplished by a system of levers. Lever operation (Fig. 7-3) is used to multiply the force of the solenoid in handling a larger valve or greater pressure drop.

Solenoids cannot actuate large valve or valves with high pressure-drops without use of undesirably large solenoid currents. For such service, therefore, the solenoid operates a small pilot valve (Fig. 7-4) to admit line pressure for operation of the main valve.

For on-off control, particularly where short valve strokes are needed, solenoids offer a uniquely high speed of response. They are used coupled either directly to the valve stem or indirectly to the stem through mechanical-advantage or pneumatic-advantage mechanisms (such as pilot orifices).

Most commercial solenoid valves use a single sustained level of power energization, which limits the power output of the solenoid to that obtainable with a current whose I^2R-developed heat can be dissipated by the solenoid. In a-c solenoids the heat due to hysteresis and eddy currents also enters the picture.

One technique for overcoming this heat-dissipation problem is the use of high source voltages with a latch-in plunger action which automatically disconnects the coil from the source, as shown in Fig. 7-5. The single-pulse valve-closing solenoid is disconnected from the power high-voltage source by the single-pulse delatch solenoid, and hence does not heat up after it is closed. A pulse to the delatch solenoid permits the valve to be

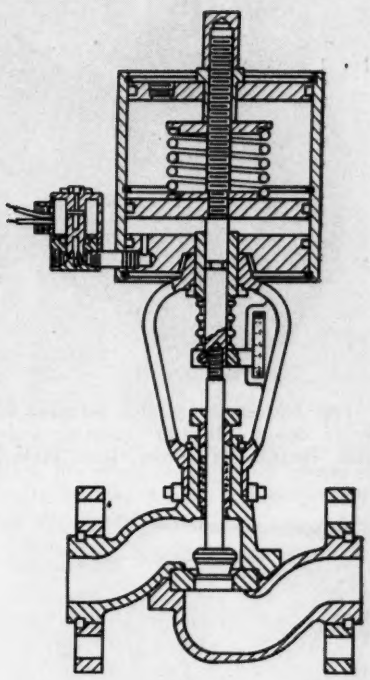


Fig. 7-4. For larger valves or for high pressure drop, the solenoid can be used to operate a small pilot valve that controls pneumatic or hydraulic pressure to a pneumatic operator.

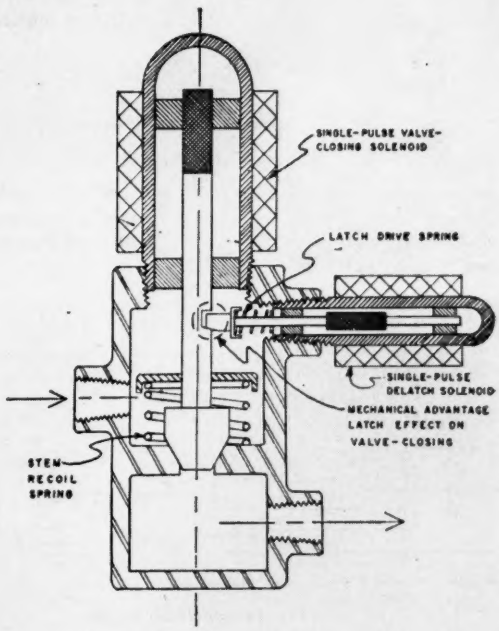


Fig. 7-5. Pulsed engagement with pulse-detach solenoid permits use of higher voltage source for shorter interval.

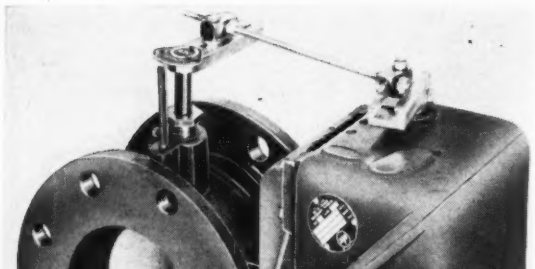


Fig. 7-6. Electric motor actuator for butterfly valve. Valve opens with 180° rotation and closes upon next 180° rotation of unidirectional motor.

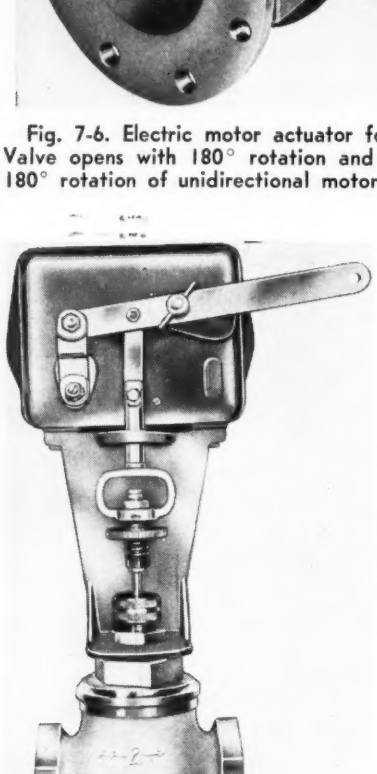


Fig. 7-7. Linkage for translating rotary motor action into vertical stem motion.

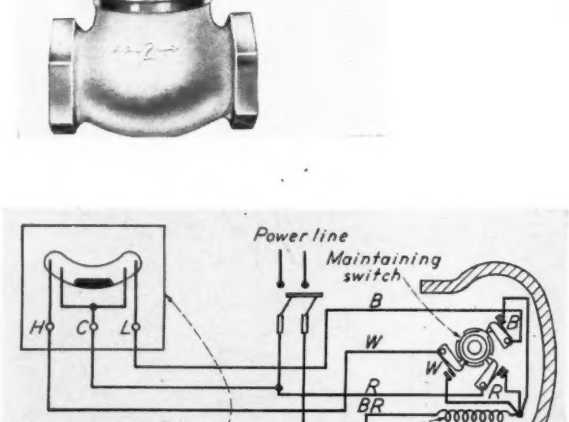


Fig. 7-8. Mercury switch (attached to 2-position controller) causes motor to drive unidirectionally. Maintaining switch causes motor to rotate drive arm 180 degrees each time a mercury contact is made.

opened by the spring. Pulsed engagement would permit use of surges from thyratrons, ignitrons, etc.

Solenoid-operated valves are used extensively for emergency shut-off service or automatic opening of a valve simultaneously with the operation of a pump or other piece of equipment. Automatic-control application should be confined to large-capacity systems such as control of liquid level in a large storage tank. (In this case, a float-operated electric switch would energize a solenoid valve on the influent line when the level is lowered to a predetermined point. The valve would stay open—due to a holding circuit—until the float reaches desired level.)

Many electric valves used for emergency shut-off are magnetic, but cannot be considered as solenoid-operated. The valve can be a globe type or a rotating-gate type. In either case, the valve is held open by electro-magnets. Upon loss of current (due to the action of a pilot switch or failure of electrical service) the valve closes by a combination of spring action, weight of the parts and, sometimes, fluid flow in the line. In most installations it is advisable to use some method to preclude the possibility of opening the valve before the emergency has been eliminated and normal operation made possible.

Small solenoid valves can be used as pilot valves in many different ways, limited only by the imagination of the user.

Electric-Motor Actuation

Electric motors were among the first valve actuators—even before the requirements of automatic control became as exacting as they are at present. Advances in design of electric actuators have been made both in the systems by which the valve can be moved rapidly to any degree of opening, and in the control systems allowing opening or closing from any intermediate position.

Fig. 7-8 shows a mercury switch for control of a unidirectional motor. The mercury switch is connected mechanically to a 2-position controller. The circuit allows the motor to operate until the commutator of the switch and the corresponding drive arm rotate 180 degrees. Reversal of the 2-way controller (or mercury switch) moves the drive arm forward through another 180 degrees. Thus the motor actuator will drive a valve (such as the butterfly shown in Fig. 7-6) completely closed with 180-degree rotation and completely open upon additional 180-degree rotation. The result is "on-off" action.

The linkage between the actuator and the valve can be adjusted so that the valve cannot move completely from "full-open" to "full closed."

Fig. 7-7 shows conventional linkage for translating this rotary motor action into vertical valve-stem motion.

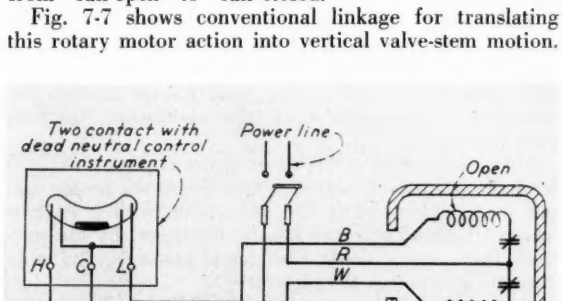


Fig. 7-9. Floating control is obtained by using reversible motor to drive valve at constant, slow speed whenever mercury contact is made.

Floating Control

In floating control, the valve moves at a constant rate either toward the open or closed position except when the controller switch is not at neutral; the valve remains in its final position whenever the switch is at neutral. It does not move again until the controlled variable moves above or below the neutral position to actuate the controller switch. Floating control is obtained by using a reversible motor to operate the valve at a slow but constant speed.

Fig. 7-9 shows a motor circuit for floating control, which has a set of stator windings for each direction and two tandem-connected rotors. The mercury switch is shown in a neutral position. When the controlled variable (such as level) causes the mercury to close contact C-L, the coil causing the motor to *open* the valve is energized. The motor rotates until a limit switch stops the rotation or until the mercury controller switch breaks. When the controller switch is in the neutral position (not contacting either H or L) the motor remains stationary.

Large valves can be operated electrically by gearing the motor drive to rotate the stem (Fig. 7-10). The motor must be of the reversible type, and it is essential that a manual de-clutching arrangement be used to disconnect the motor and connect a handwheel for manual operation. One design (Fig. 7-11) uses a friction device to disconnect the handwheel-driven gear as soon as the motor starts. When the motor stops, the friction force caused by rotation is removed so that a spring reconnects the handwheel automatically.

Proportional Control

Most modern control systems require proportional control. In proportional control there is a definite valve position corresponding to each value of the controlled variable (within the proportional band). Thus, the valve must go from full open to completely closed as the controlled variable moves from one extreme of the proportional band to the other.

The circuit shown in Fig. 7-12 can be used to obtain proportional control. Two slidewire resistances (potentiometers) are used. The movable slider of one is positioned by the control instrument and is responsive to the controlled variable (level, flow, etc.); the slider of the other is positioned by the valve stem. The two slidewire resistors are used as the legs of a Wheatstone-bridge circuit. A balancing relay causes rotation of the motor in the direction necessary to set the valve resistor at a position corresponding to that of the controller resistor.

This system for positioning can be used on almost any valve which is actuated by a reversible motor.

Stem Force Factors

When using an electric motor it is necessary to use a device to stop the motor at either the closed or open position, or whenever the valve becomes blocked, as when trying to close on foreign matter in the line. Further, it is not sufficient to use limit switches (at least not for detecting a closed position) because it is necessary to seat the valve with enough force to minimize leakage. For this reason, a method for recognizing and limiting the *stem force* must be furnished.

This can be done mechanically by use of a *differential clutch* between the gears driving the valve stem and a rod, which can act upon a stopping switch. With nothing hindering the rotation of either of the gears, they will

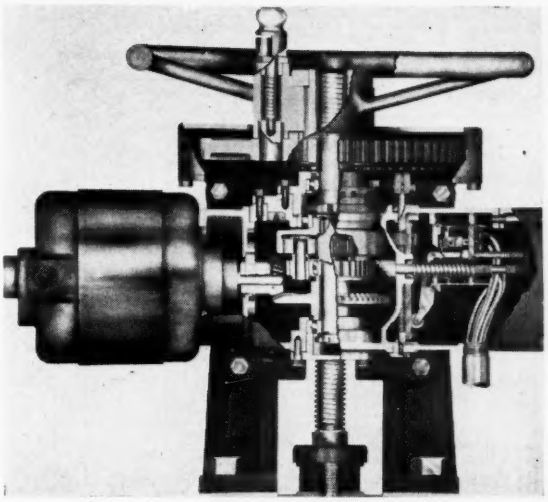


Fig. 7-10. Large valves can be driven by gearing the motor drive to rotate the stem. De-clutching arrangement permits motor to be disengaged, and handwheel engaged, for manual positioning.

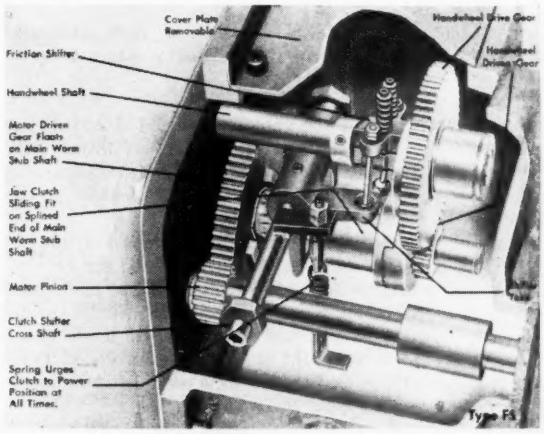

Cover Plate Removable
Handwheel Drive Gear
Handwheel Driven Gear
Friction Shifter
Handwheel Shaft
Motor Driven Gear Floats on Main Worm Stub Shaft
Jaw Clutch Sliding Fit on Splined End of Main Worm Stub Shaft
Motor Pinion
Clutch Shifter Cross Shaft
Spring Urges Clutch to Power Position at All Times.
Type FS

Fig. 7-11. Friction clutch automatically engages handwheel when motor drive stops, and automatically disconnects handwheel-driven gear when motor starts.

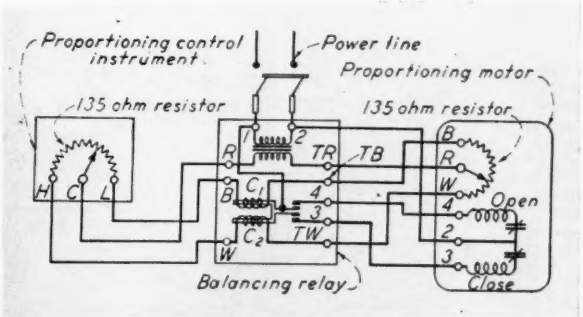


Fig. 7-12. Circuit for obtaining proportional control is essentially a Wheatstone bridge. Slidewire at left is positioned by control instrument; slidewire at right is positioned by valve stem. Hence motor follows a change in variable and applies proportional corrective drive.

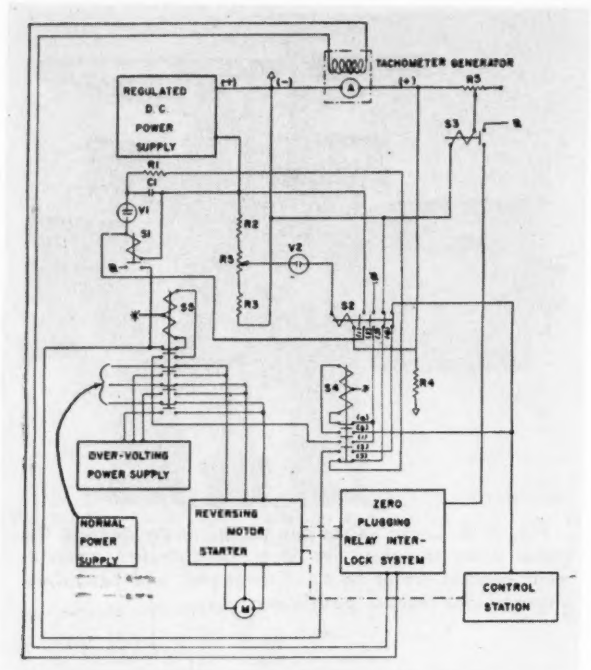


Fig. 7-13. Circuit for "over-volting" and accurately stopping a squirrel-cage induction-motor valve drive.

move together. When the valve is obstructed and its gear set stops, the motor will continue to exert force on the remaining gears, and they will start to turn separately. This new rotation is transferred to the element used to shut off the electric power to the motor.

Another type of electric actuator employs a *strain gage* to detect the stem force at each end of the stroke.

Electric actuators for gate valves must use some method to *unseat* the wedge before the valve can be opened. This is done in several mechanical ways. They consist essentially of allowing the motor to gain speed before contact is made with the end of a slot. This imparts a hammer blow to unseat the valve.

Most motor actuators originally were designed for remote operation of large valves, using a push button to energize the motor, and with speed of stem motion (which can be varied by changing gears) of about 20 inches per minute. A majority of the applications were for on-off control so that hammer blow (for unseating) and limited torque control (at the ends of the stroke) were adequate, if necessary, features.

Adaptation of this equipment to proportional-control service where position and direction of motion are dictated by a controller must take additional variables into consideration. Good control requires that the valve start to move immediately and move rapidly upon any small change in controller output; and that it come to a stop in the position required to satisfy the new condition. This is particularly true if the rate of change of valve position is constant, as is the case with many electric-motor actuators.

Both static and dynamic loads on the motor actuator vary for every operating condition, as for all other actuators. The previous discussion in Chapter 5 pointed out that the static forces due to flow vary, and even reverse, depending on the diretcion of flow, type of valve, and position of valve. Dynamic forces, consisting of hysteresis and unbalance, also vary with the direction of stem travel. Thus, even if gear-train efficiency were increased to allow use of smaller motors, and if the total load were decreased to permit faster valve-movement, the problem of variable load would still exist.

Over-Volting

The actuator motor can be "over-powered" to obtain sufficient starting torque for gaining speed. This tends to contribute to overshooting the desired position (hunting). Use of worm drives assists both in rapid coming to rest and in obtaining the necessary power. Speed of reaction is increased also by the use of planetary gears, which, however, tend to increase hunting.

One design (Fig. 7-13) uses "over-volting" for starting. A higher-than-normal voltage is applied during the period from the initial closing of the circuit until maximum motor speed has been attained. The speed is sensed by a tachometer-type generator.

Immediate stopping of the motor with no coasting is also necessary for this system. This is accomplished by

Fig. 7-14. Circuit for control of valve stem speed in response to error signal and stem loading force. Stem force is sensed by strain-sensitive resistor mounted on stem.

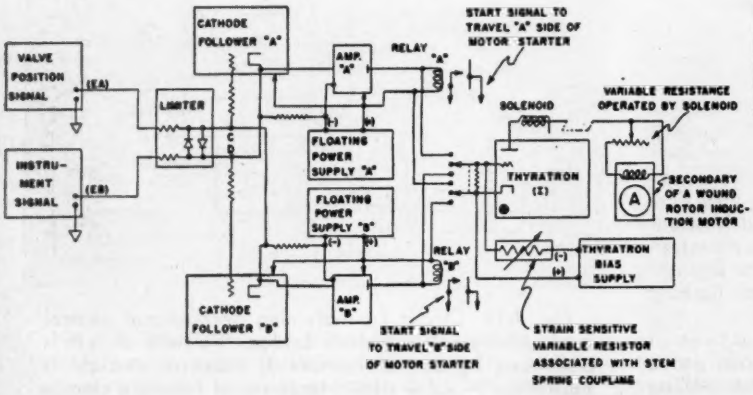
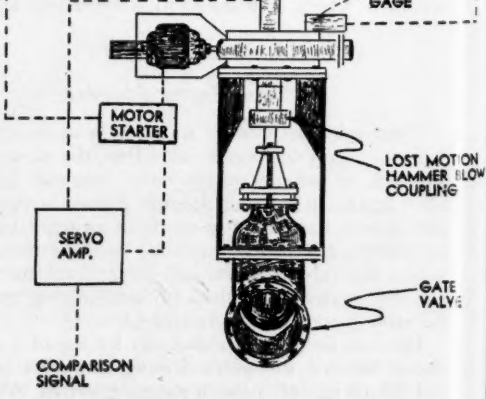


Fig. 7-15. Equipment for circuit shown in Fig. 7-14.



a conventional "plugging" switch (which uses the same tachometer used during starting). The output of the generator operates a relay to activate an additional field in the motor which is designed to offer braking action. This field is energized at the instant that the controller recognizes that the necessary valve position change has been accomplished.

Control instruments with refinements in the feedback loop (such as rate response) require that the valve speed be adequate. The pneumatic actuator does, within limits, follow the *rate of change* in controller output as well as the quantitative change. The electric actuator must do the same for full acceptance by the design engineer.

The block diagram in Fig. 7-14 illustrates a method for control of valve stem speed in response to both an error signal and the stem loading force. The equipment is shown in Fig. 7-15. The control reduces the speed as balance position is approached by varying the series resistance in the secondary of a wound-rotor induction motor. The same technique can be applied to any a-c or d-c motor whose speed can be varied by using a variable transformer or a continuously adjustable resistance in the field winding and/or rotor winding.

Gas and Air Motors

Conventional reversible gas motors of the rotary or piston type have been adapted for use in operating valves of almost all designs, including sliding stem, plug valves, or gate valves (Fig. 7-16).

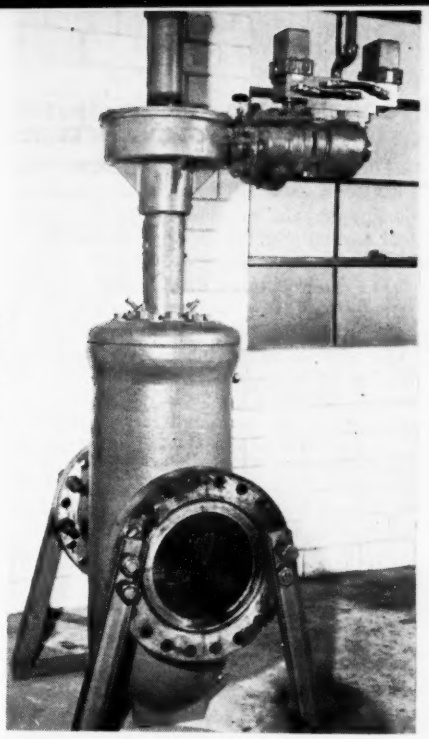


Fig. 7-16. Gas motor actuator. Motor is reversed by solenoid pilot valves.

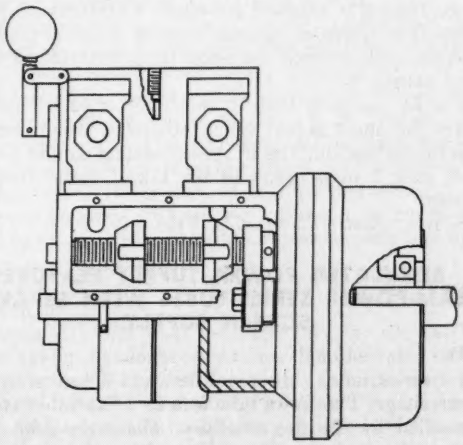
Many actuating units designed for electric-motor operation can be driven with a gas motor. Reversing action can be accomplished with a four-way solenoid or with a diaphragm-operated pilot valve. The resulting control mode is *floating control*, similar to the system described under electric motors; the valve continues to move at a constant rate in one direction until it reaches a limit switch, or until the controlled variable produces a reversing signal. Special features (similar to those embodied in the electrically controlled valve) make possible the control of the seating force in the closed position, and also the acceleration of the motor before the opening motion begins.

One successful form of pneumatic motor control is shown in Fig. 7-17. Here the limit stops contact fingers which operate two pilot valves that control the flow of high-pressure air or gas used to power the motor. The limit cams can move backward or forward without change in relation to each other while the cam shaft is rotated by the driving motor.

Many desirable features have been incorporated in the valve actuator shown in Fig. 7-18. Accurate setting of the valve is accomplished by a valve positioner which senses stem position through the movement of a stainless-steel tape. The air signal from the controller is fed to valve positioner which controls the pilot valve, which in turn controls the air motor. The motor moves until it reaches a position which corresponds to the output signal from the instrument controller.

Gas-motor actuators, like electric-motor actuators, offer the advantages of (1) maintaining their last position upon loss of power, (2) allowing long stem travel, (3) high power through gearing, (4) readily adaptable to manual operation, and (5) stability at any valve position.

Fig. 7-17. Adjustable limit stops determine the valve travel in this gas-or-air-motor actuator design.



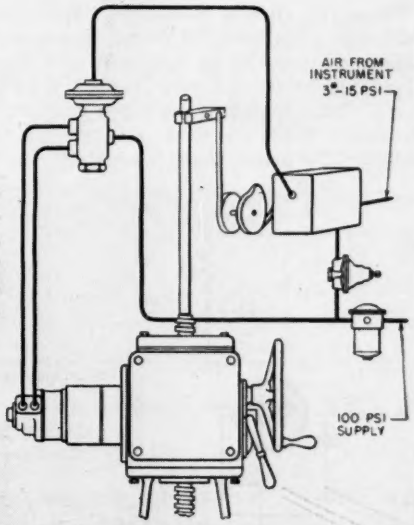


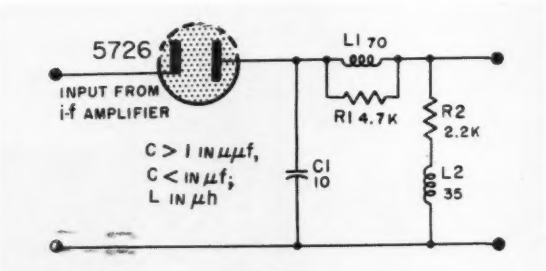
Fig. 7-18. Pneumatic motor actuator that senses valve position by mechanical feedback via a stainless-steel tape.

ELECTRONIC

COMPENSATED VIDEO DETECTOR HAS 0.07 MICROSECOND FALL TIME

This video detector (NBS-BuAer Preferred Circuit PC20) is used to demodulate pulsed intermediate-frequency signals, as in radar receivers. Output of detector will normally be fed to video limiter PC21 (*I&A, March,* 1956).

The diode is one-half of a 5726, a premium version of type 6AL5W. It is connected for negative pulse output, as required by the following limiter. Linear operating range extends from about 0.2 to over 4 v; nominal operation level is 0.6 v.



Input capacity is about 14 uuf, consisting of 4 uuf for the 5726 and wiring, plus the 10 uuf capacity of C_1. Shunt capacity of following stage is also 14 uuf (10-uuf wiring plus 4 uuf for input capacity of following 5654 stage). Hence fall time is 2.2 RC = 2.2(2.2K)(28 uuf) = 0.136 usec.

Components L_1-R_1-L_2 are added to reduce the fall time of the output pulse. Without compensation, fall time is 0.136 usec. Compensation reduces fall time by a factor of 2.06—to 0.066 usec—with 3% overshoot. Inductor L_1 (70 uh) is wound to be self-resonant at the i-f frequency.

Input: I-f pulses, 20-70 Mc.

Output: Rectified negative pulses, 0.6 v nominal level.

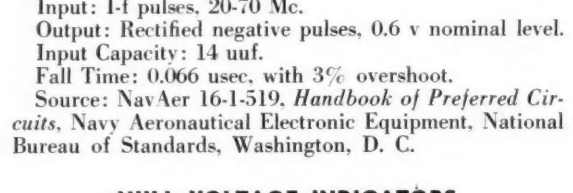
Input Capacity: 14 uuf.

Fall Time: 0.066 usec, with 3% overshoot.

Source: NavAer 16-1-519, *Handbook of Preferred Circuits,* Navy Aeronautical Electronic Equipment, National Bureau of Standards, Washington, D. C.

NULL VOLTAGE INDICATORS

These two circuits are used in FM receivers as tuning indicators. The left-hand circuit uses a 6J6 dual triode tube and a type NE-51 1/25-watt neon lamp; it is used in the Sonocraft FM tuner. Output of the FM discriminator is direct-coupled to one triode grid; the other grid is grounded. When the receiver is correctly tuned, the d-c output of the discriminator is nearly zero volts. Hence the plate currents of the two halves of the tube are nearly equal, and the difference between the two plate voltages is less than the 75 volts needed to light the neon lamp. If the receiver is improperly tuned, there will be a positive or negative d-c voltage at the discriminator output; about 2.5 volts output is enough to cause the lamp to light.



When a d-c voltage is applied to the neon lamp, the more negative plate glows. Thus, one plate glows when the receiver is tuned above the carrier frequency and the other when it is below the carrier. Neither plate glows when the set is tuned closely to the carrier frequency. It should be noted that the plate voltage of the right-hand half changes when input is applied, even though its grid is grounded. Voltage changes at the common cathode, produced by the changing plate current of the left-hand triode, produce a grid-to-cathode voltage on the right-hand half of the tube. Plate swing of the grounded-grid section is only about one fourth that of the input section.

The second tuning indicator circuit is used in a British FM set and was described in *Wireless World*. It is similar to the first but uses a 12AX7 tube with a neon lamp in series with each plate. If the discriminator output voltage is positive, plate current of the input triode increases and its lamp glows brighter. At the same time, the increased drop across the common cathode resistor increases the bias on the other tube section and its plate current drops, dimming the lamp in its plate circuit. When the discriminator output is negative, the reverse effect takes place. Tuning is adjusted for equal brightness of the two lamps. The common cathode resistor value is made sufficiently high to hold the neon lamp currents to within rated values.

The RC low-pass filter at the input of each circuit removes the audio signal which otherwise would interfere with the indication. The RC time constant should be equal to at least 3 or 4 cycles of the lowest audio frequency present.

Source: *Radio-Electronics,* February, 1956

REGULATED POWER SUPPLY FEATURES BEAM-POWER SERIES-TUBES WITH SEPARATE SCREEN SUPPLY

The conventional series-tube-regulated power supply has a series tube, a d-c amplifier, and a source of reference voltage. The series tube acts as a "variable resistor" controlled by the d-c amplifier. The series-tube should have high efficiency (low plate-voltage drop) and high

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Instruments and Automation

CIRCUITRY

The circuit is the heart of all electronics. Here are 5 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

gain (for good regulation). Unfortunately, high-gain tubes have low efficiency, and vice versa. Hence either low-mu triodes (which can pass large current with little plate-cathode voltage drop) or triode-connected beam-power tubes (which have higher amplification factor but larger plate drop) are used commonly. This circuit uses a beam-power pentode (for high gain) with a *separate screen voltage source* to attain a higher amplification factor than is possible with a triode-connected beam-power tube. Its efficiency approaches that of a low-mu triode.

The circuit shown is similar to NBS-BuAer Circuit PC3A, with the basic difference that a beam-power series tube and an additional d-c amplifier input stage are used in this circuit.

The filtered but unregulated voltage is applied at E_1, and passes through the two 6098/6AR6WA series tubes. Any variation in output voltage is first amplified by V5B and V5A. For example, a decrease in E_0 causes a positive signal at plate of V5B, and a negative signal at plate of V5A. Both signals are applied to the final d-c controller stage V3A (the latter directly, the former through stage V3B) to cause the grids of the 6AR6 to go more positive, restoring the output voltage.

Network R9-C1 provides negative feedback around stage V3A to reduce its gain at high frequencies and thus prevent instability, which might occur at some high frequency due to phase shifts in the amplifier circuit.

For the 6098/6AR6 tubes shown, the separate screen supply is a 150-v selenium-bridge-rectifier RC-filtered unregulated supply. Beam-power pentodes 6CU6/6BQ6 also can be used with a separate screen-supply of 90 v and 12 ma.

Output capacitor C4 should be 4 or 8 uf.

All heaters are maintained at a d-c voltage level that is one-half the output voltage by the 68K-ohm voltage divider across the filament supply winding.

The regulated output can be used as the screen supply for a lower-voltage source, as shown in B. This is important because whereas the added regulation might not justify the cost of a separate screen supply for the beam-power tubes, particularly in view of the fact that adequate supplies can be made without this feature, a system of regulated supplies can be obtained by use of only one added screen supply, as shown.

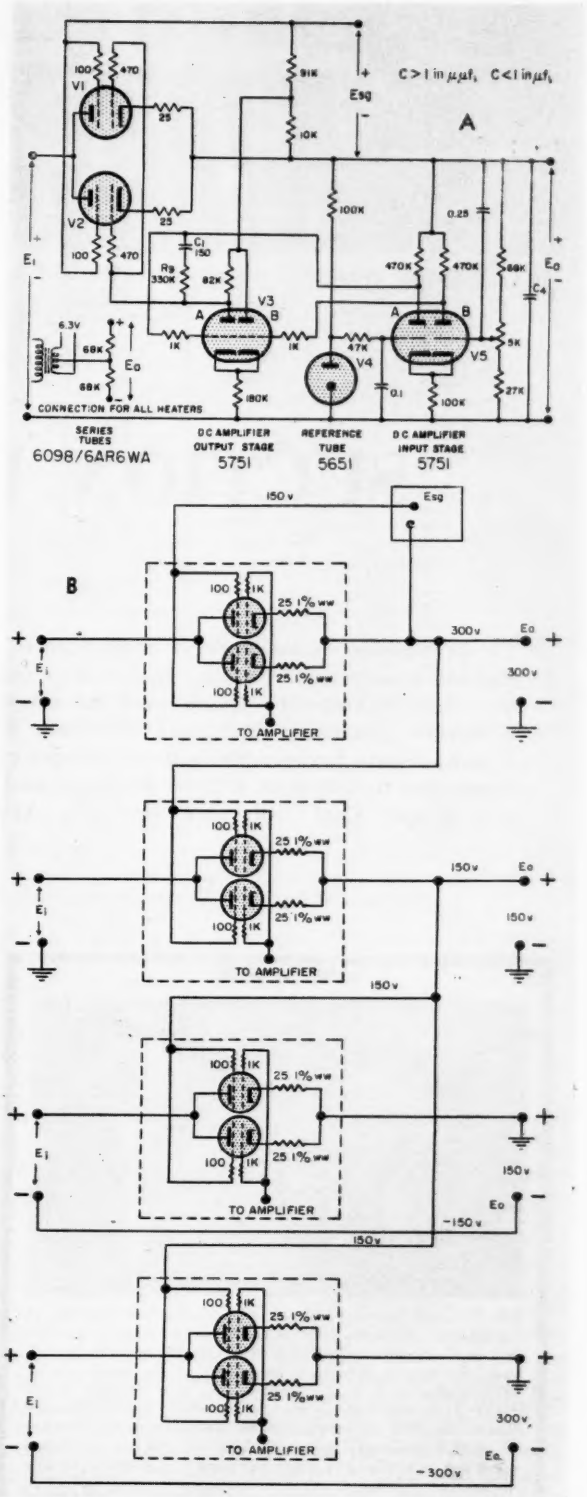
Input E_1: 335 volts at full load (200 ma) and minimum line voltage.

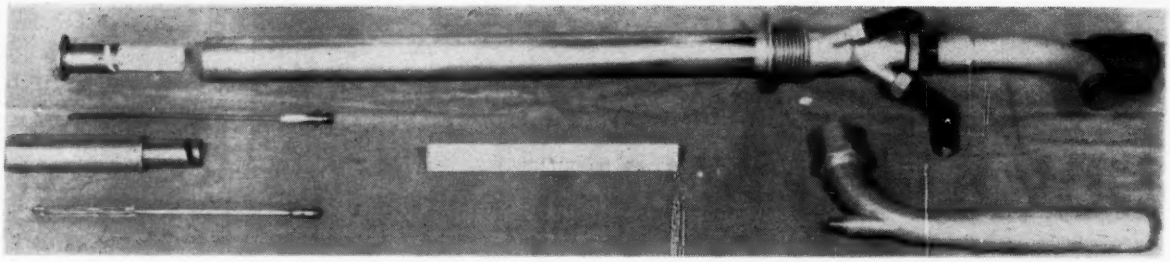
Output E_0: 300 volts regulated at 200 ma (100 ma per tube).

Regulation: With 6098/6AR6 tubes, output varies less than 0.2 v for 25% variation in load, and ± 10% change in line voltage (when input voltage ripple is less than 1 v and screen-voltage ripple is less than 0.5 v). If input voltage ripple is 30 v and screen-voltage ripple is 1 v, then output ripple is 1 mv.

Output Resistance: less than 1 ohm from dc to over 150 kc.

Source: S. Rubin, National Bureau of Standards, Washington 25, D. C., in Summary Technical Report 1935.





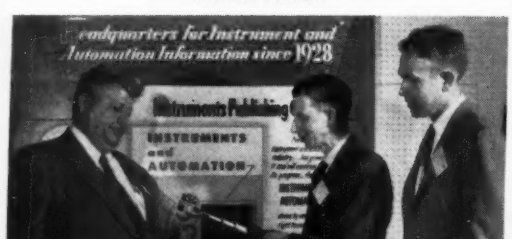
The Land suction pyrometer, now offered in the USA by Fielden Instrument Div., Robertshaw-Fulton Controls Co.

SUCTION PYROMETRY

Thermocouples measuring gas temperature must be protected from radiant heat transfer to or from surrounding walls, and the hot gas must be moved rapidly past the thermocouple. The result is a suction pyrometer. The work described has resulted from friendly co-operation between the author's company and two research associations—the British Iron & Steel Research Association (B.I.S.R.A.), and the British Coal Utilization Research Association (B.C.U.R.A.).

T. LAND
Land Pyrometers Ltd.
Sheffield, England

THE AUTHOR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Mr. T. Land (center) studied mathematics and physics at Cambridge University. He took an honours degree in 1935 and received the degree of Master of Arts in 1940. For six years he was in charge of pyrometry at the steelworks of William Jessop & Sons, Limited, and later became Senior Physicist to the Birmingham Small Arms Group Research Centre. In 1950 he established his own instrument company of Land Pyrometers Limited, in Sheffield. He has published numerous scientific and technical papers in England, mostly on subjects relating to steelworks pyrometry, and served on several research committees of the British Iron and Steel Research Association.

He flew to this country from England to deliver this paper at the Pittsburgh Section ISA Iron & Steel Conference, March, 1956. He is seen above showing the Land surface pyrometer to Carl Yeager, left, (Chief Combustion Engineer, Jones & Laughlin Steel Corp., Cleveland) and Chas. Swartwout (The Swartwout Co.).

DURING the last five years there has been a recognition in Britain of the need to measure accurately the temperature of hot gases in power stations, steel melting furnaces, glass tanks, and other industrial operations—not only to increase production but to economize in use of fuel.

A sheathed thermocouple in a room assumes a temperature roughly midway between the temperature of the air and that of the walls. At higher wall temperatures, radiant heat transfer increases and the thermocouple temperature approaches that of the surrounding surfaces. To measure gas temperatures, the thermocouple must be protected from radiant heat transfer to or from the walls by surrounding it with a system of radiation shields. Also, the hot gas must be sucked past the thermocouple and shields at a high velocity to increase convective heat transfer. The result is a *suction pyrometer*.

The suction pyrometer has been developed and used in Germany, notably by Schack[1], and in the United States by such workers as Mullikin and Osborn[2], and Marsh[4]. An extensive bibliography of the subject has been given by Mullikin[3].

The problem of prime importance, the accuracy of measurement, was recognized by Marsh, who took care to determine how many radiation shields were necessary for the conditions of operation which he encountered. However, there has been no general theory of the suction pyrometer. The author and his co-workers, therefore, tackled first the mathematical theory of the instrument.

Table I.—Efficiency (%) for Sheathed Thermocouples with Multiple Blackened-Metal Radiation Shields and Gas Velocity of 500 ft/sec.

Temperature	Number of Radiation Shields									
	1	2	3	4	5	6	7	8	9	10
400°C (732°F)	98									
600°C (1112°F)	88	98								
800°C (1472°F)	71	93	98							
1000°C (1832°F)	54	81	93	97	99					
1200°C (2192°F)	39	69	85	92	95	98	99			
1400°C (2552°F)	28	55	74	83	91	95	97	99	99	
1600°C (2912°F)	20	43	62	73	83	90	94	96	97	98

Table II.—Effect of Gas Velocity on Multiple-Shield Suction Pyrometers

Velocity (ft/sec)	10	20	50	100	200	300	400	500	600	700
Equivalent number of shields at 500 ft/sec	0.21	0.28	0.40	0.52	0.69	0.82	0.93	1.00	1.07	1.14

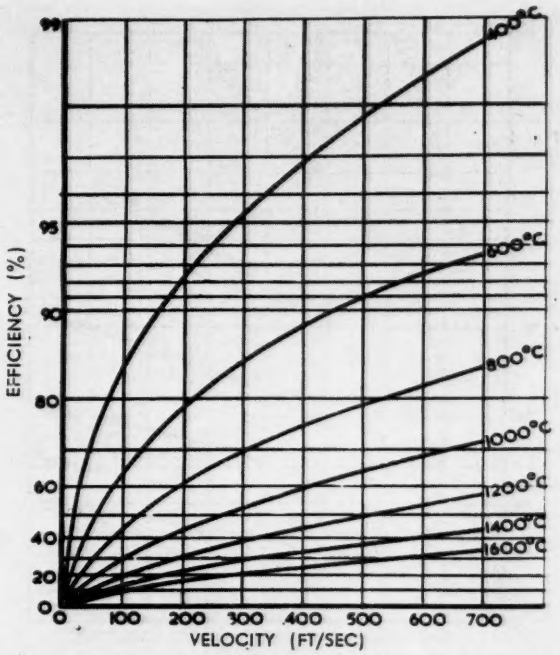

Fig. 1. Efficiency of suction pyrometer with blackened metal sheath and one radiation shield.

The theory is a little complicated and need not be repeated here; the results of the calculations were published recently[5]. Fortunately, the results are relatively simple and can be understood and applied easily. The theory is based on the established equations for radiant and convective heat transfer, and shows satisfactory agreement with experimental and published results.

The calculations establish the error of a suction pyrometer, with a view to making instruments with negligible errors. The errors need be calculated only with an accuracy of ±50%, so that approximate solutions are acceptable. It must be emphasized that the calculations are not intended to produce corrections which can be applied to instruments; they are intended as a guide to design.

Efficiency of a Suction Pyrometer

In designing a suction pyrometer one must decide first how many radiation shields to use and what gas velocity to employ. It is good practice to aim for a gas velocity through the radiation shields of from 500 to 700 ft/sec. High velocities are attained by converting part of the thermal energy of the gas into kinetic energy. Velocities above 700 ft/sec can cool the gas appreciably, but it is difficult to get a velocity of 700 ft/sec with conventional fans and ejectors. Sometimes one must be content with a velocity of only 100 or 200 ft/sec.

An important concept in suction pyrometers is the "efficiency" of the instrument. Suppose that a suction pyrometer is first put into the furnace without the suction turned on; it will indicate a temperature differing from the true gas temperature by an amount Θ_0. When the suction is applied, Θ_0 will be reduced to Θ. Thus the *efficiency* of a suction pyrometer is the ratio:

$$\frac{\Theta_0 - \Theta}{\Theta_0}$$

An efficiency of 95% is usually satisfactory. If the temperature of the surrounding surfaces does not differ greatly from the gas temperature, a pyrometer with an efficiency of only 80% might be acceptable.

Design Data

Many suction pyrometers are made with metal radiation shields whose surfaces rapidly become oxidized and may then be considered to be black. Efficiencies of suction pyrometers at different temperatures, using "blackened" metal shields and thermocouple sheaths, are shown in Table I for a hot-gas velocity of 500 ft/sec. The efficiency improves with number of radiation shields. The effect of reducing gas velocity is the same as reducing the number of radiation shields by a factor; that factor is given in Table II.

An example typical of the air preheat in the uptake of an open-hearth furnace illustrates the use of the table. A pyrometer with metal radiation shields is used to measure a gas temperature of 2000°F. With the suction turned off the pyrometer indicates 2400°F. A gas velocity of 500 ft/sec through the radiation shields can be obtained. Accuracy of 20F°, or an "efficiency" of 95%, is required. The mean temperature of the shield system is about 2200°F. Table I shows that for 95% efficiency we need five concentric radiation shields of oxidized metal.

If the gas velocity dropped to 100 ft/sec, Table II shows that the effective number of shields would be halved. From Table I we see that the efficiency would drop from 95% to about 80%, and we would expect an error of about 80F°. For lower temperatures, only one or two radiation shields need be used.

Efficiency of a pyrometer with a single blackened metal shield is shown in Fig. 1; for two shields the efficiency is

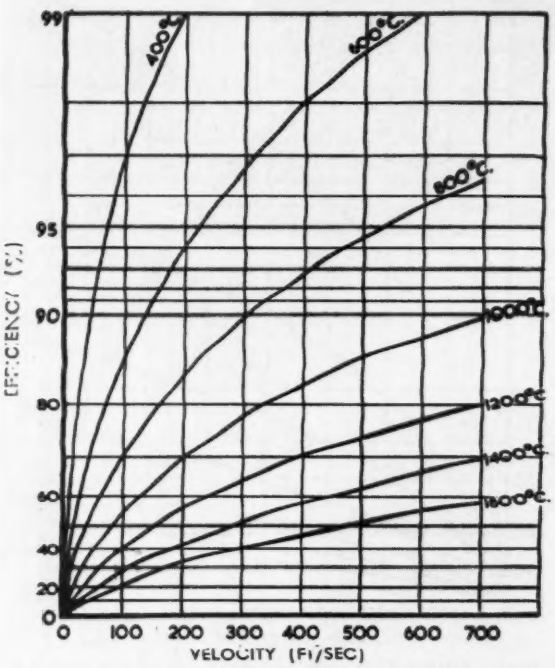

Fig. 2. Efficiency of suction pyrometer with blackened metal sheath and two radiation shields.

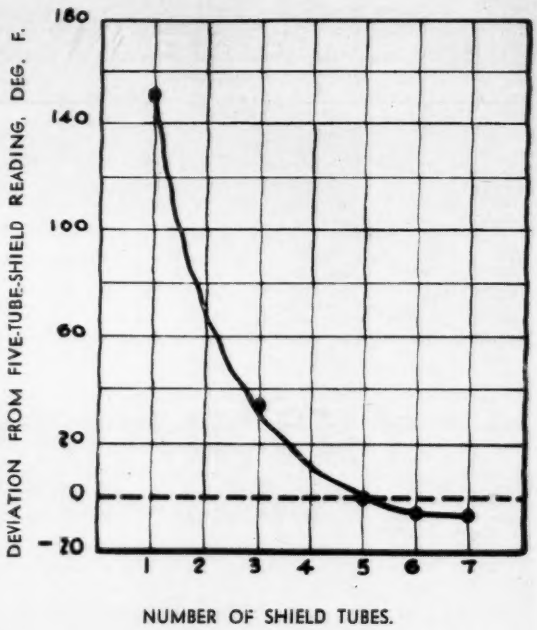

Fig. 3. Experimental results with pyrometer having 1, 3, 5, 6 and 7 radiation shields (Marsh).

given in Fig. 2. *Table I is accurate only for multiple shields;* the columns of figures for 1 and 2 shields are included in the table for pyrometers with multiple shields working at low velocities.

The use of a bare platinum thermocouple greatly improves the accuracy of a suction pyrometer. Unfortunately, it is rarely possible to use such a couple unprotected in industrial gases because it becomes contaminated rapidly. A base-metal couple sometimes can be used without a sheath, and the advantage is roughly equivalent to using one additional radiation shield.

Refractory Radiation Shields

Note that Table I indicates the need for large numbers of radiation shields at high temperatures. However, much fewer shields are needed if refractory materials are used. This is due to the fact that refractories have much lower emissivities than oxidized metals like nickel, and also have lower thermal conductivity. The *emissivity* is usually the important factor.

It is found in practice that one refractory radiation shield is roughly equivalent to two oxidized metal shields. Thus, two refractory shields give tolerable results in measuring the preheated air temperature in an uptake. Three shields give accurate results.

Service Tests

How can we test a suction pyrometer in service?

Marsh constructed a series of different pyrometers of increasing complexity. He compared results obtained by adding radiation shields until he found no improvement in performance with addition of extra shields (Fig. 3).

An easier method, which has been used more widely, is to increase the gas velocity through the radiation shield in increments and to plot a curve of temperature vs velocity. This is not quite as easy as it sounds because the process takes a long time and the gas temperature can change considerably during the test. The curve of temperature vs velocity shown in Fig. 4 indicates the accuracy of measurements and gives convincing evidence that the temperature is being measured correctly. It is more difficult to interpret results such as those shown in Fig. 5.

A New Test Method

The mathematical theory of the suction pyrometer shed new light on methods of testing in service. First, it revealed the shape of the curve relating temperature and velocity. All pyrometers with multiple radiation shields yield a temperature-velocity curve of a standard shape. Thus comparison of experimental results with this theoretical curve is possible. The curve can be extrapolated with reasonable confidence so that the efficiency of the pyrometer can be determined.

This is still a tedious method of testing, and a simpler procedure is to operate the pyrometer at full velocity and record the temperature while the gas flow is measured with a Venturi and manometer. To carry out the test, the gas flow is *halved* for two or three minutes and then turned *off* altogether. The recorded temperature goes up (or down) in two steps. The full flow is then restored.

The accuracy of the pyrometer is assessed in the following simple manner: The heights of the two steps in the temperature record are measured. The effect of turning off the suction completely should be much greater than that of halving the gas flow, so that there is a small step and a big one, as shown in Fig. 6. If the big step is less than seven times as high as the small one, the pyrometer is not operating with accuracy. The error is then greater than the height of the small step. If the ratio exceeds 7:1 the height of the small step is a good estimate of the error of the pyrometer with full suction.

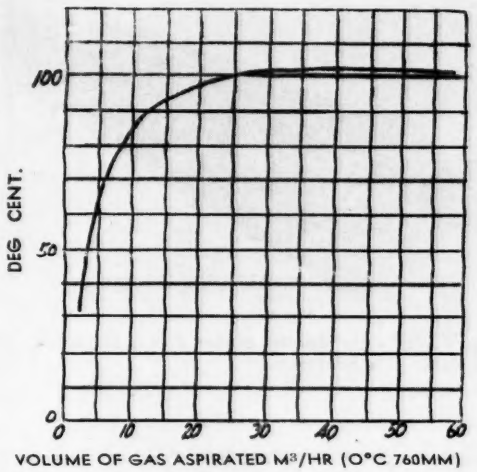

Fig. 4. An experimental curve relating indicated temperature to gas velocity. The long flat portion of the curve shows that the true gas temperature has been attained (Wenzl and Schulze).

A warning must be added that turning off the suction completely can mean plugging the gas outlet. There is frequently a sufficient pressure in the furnace to create appreciable flow of gas through the pyrometer without aspiration.

Alternate Test Method

The theory suggested a second method of testing pyrometers in use. Although it is not quite so easy to carry out accurately as the "method of half velocity," its chief merit is that it gives a second, completely independent method of checking the efficiency of the pyrometer. As the two methods have been found to agree, either can be used with confidence.

The basic idea of the test is easily understood: If the suction is suddenly turned off, the thermocouple cools off (or heats up) by *radiation* alone. The radiation shields insure that this is a slow process. If the suction is turned on again, the couple heats up (or cools off) chiefly by *convection*. If the pyrometer is accurate, the convective heat transfer will be much greater than the heat transfer by radiation. Therefore the temperature will reach equilibrium much more quickly when the suction is turned on, than it did when the suction was turned off.

This forms the basis of the second method of testing. The suction is turned off and left off for a sufficient time for the temperature to reach a steady value. It is then turned on again. The temperature is recorded on a chart having a large enough scale for times and temperature changes to be read accurately. The time constants for heating and cooling are measured from the chart.

To find the "efficiency" of the pyrometer the ratio of the small time-constant to large one is found and squared, and the result is subtracted from unity*. Thus:

$$\text{Efficiency} = 1-(\tau_1^2/\tau_2^2)$$

where τ_1 is the small time-constant and τ_2 is the large time-constant. (The time constants may be defined as "the time taken to complete nine tenths of the total temperature change.")

An example helps to make the method clear. Suppose that on switching off the suction and plugging the gas

*If only a single radiation shield is used this formula is not applicable. Then we must take: Efficiency $= 1-2(\tau_1^2/\tau_2^2)$.

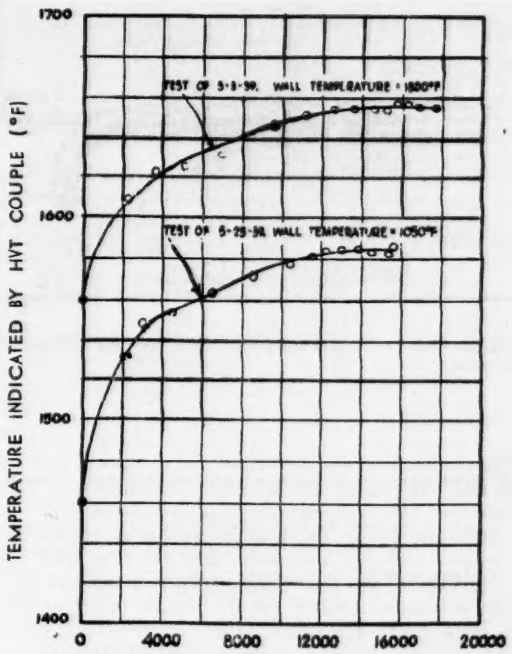

Fig. 5. Experimental curves having a less satisfactory shape than Fig. 4. It is not at all obvious that the true gas temperature has been attained (Mullikin).

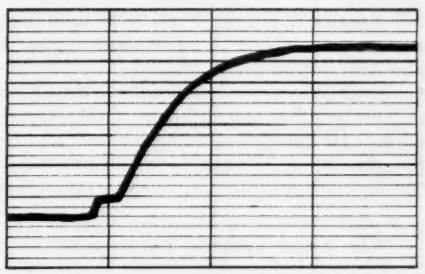

Fig. 6. A typical temperature record obtained when the gas velocity is first halved (giving a small step) and then reduced to zero (giving a big step). Under certain circumstances the height of the small step is equal to the error of the pyrometer at maximum velocity.

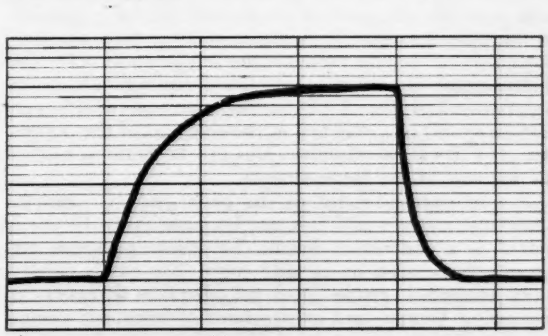

Fig. 7. The type of record obtained when the suction is turned off and then turned on again. The error of the pyrometer can be calculated from the ratio of the time constants of these two exponential curves.

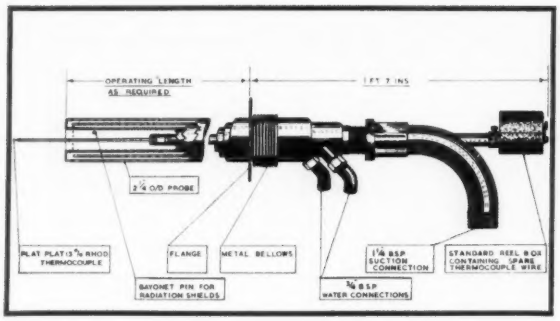

Fig. 8. The Land suction pyrometer for high-temperature gases.

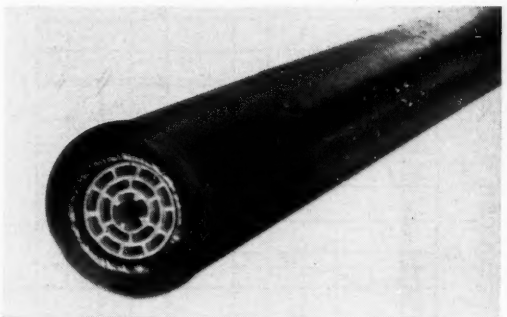

Fig. 9. The water-cooled probe with a refractory radiation shield fitted internally.

outlet, the temperature rises 200F°, and suppose that the first 180° rise takes six minutes. The suction is then switched on and the temperature quickly drops 200F° to the temperature from which we began. Let us assume that it required only two minutes to drop the first 180F° of the total 200°. The temperature record is shown in Fig. 7.

The two time-constants are six minutes and two minutes, respectively. The square of their ratio is 0.11. Hence the efficiency of the pyrometer is 89%, and the error of the instrument will be:

$$(0.11/0.89) \times 200 = 25\text{F}^\circ$$

This method cannot be used easily if the gas temperature is varying rapidly. In that event, two identical pyrometers can be used side by side. They are connected in series opposition and the temperature difference is measured. The experiment should be made in such a manner that in each measurement the difference begins with a large value and diminishes to zero.

Knowledge of this method often allows the operator to tell at a glance whether the accuracy of the pyrometer is good or poor. He just turns the suction off and then on again, and glances at the chart. For quantitative results, the "method of half velocity" is usually simpler to use.

The Land Suction Pyrometer

A series of suction pyrometers was constructed while the mathematical theory was being developed. These enabled the theory to be tested, modified and extended. The final design is shown in Fig. 8. It incorporates several important features[6]: (1) The probe is water-cooled. (2) It is made of a seamless stainless-steel tube and provided with a small bellows to allow for differential expansion of the tubes in use. (3) A platinum/13% rhodium thermocouple is used to measure the temperature. (4) The thermocouple is carried in a stainless-steel tube within the water-cooled probe. (5) Spare thermocouple wire is carried on spools in a reel box at the cold end of the pyrometer. (6) Metal or refractory tips can be fitted to protect the hot end of the thermocouple.

The internal diameter of the probe is 1⅜" and its outside diameter is 2¼". It can be made up to 15′ long, but 6′ is a convenient length. To insure adequate gas velocity there must be no side entry. The gas is carried away around a gentle bend of adequate diameter. A measuring Venturi and an aspirator of improved design can be added.

The radiation shield is a replaceable unit with an internal bayonet fitting. An Inconel shield is used for temperatures up to 1150°C. This comprises four concentric finned tubes. The fins touch the inside of the next larger tube only at the ends, to avoid thermal conduction. The Inconel thermocouple sheath is also finned. The efficiency of this system at 500 ft/sec and 1150°C is approximately 98%. An important application of the Inconel shield is for water-tube boilers.

Refractory shields and sheaths can be fitted to the same pyrometer for higher temperatures. An extruded refractory shield, comprising three concentric finned tubes, has been specially designed. It can be used up to 1700°C, in conjunction with a Mullite thermocouple sheath. At 500 ft/sec the efficiency is approximately 90% at 1600°C.

B.I.S.R.A. Water-Cooled Radiation Shield

The British steel industry has been keenly interested in preheated air temperature in the open-hearth furnace. In this field useful pioneer work was carried out by Cashmore[7].

The conventional suction pyrometer has a hard life in the uptake of an open-hearth furnace. During the half cycle when air is passing, the temperature of the refractory shield is rarely more than 1400°C, but during the waste-gas cycle the gas temperature may be 1800°C and particles of slag are carried through from the furnace. Even if the suction is turned off during the period when waste gases are passing, the refractory shield rarely lasts for more than a few hours. It softens, melts and quickly blocks up. Design of a pyrometer was sought which would run for several days without attention.

B.I.S.R.A.[8] ultimately hit upon the simple idea of enclosing the radiation shield in the water jacket. It is thus protected from excessive heat during the waste gas cycle, and the temperature of the shield is always less than that of the aspirated hot gas. The suction is turned off automatically when waste gases are passing. The pyrometer is so located in the uptake that the slag particles do not impinge on the exposed front surface of the radiation shield.

This arrangement was first intended to give an arbitrary reading, lower than the true gas temperature, which then could be corrected. It was expected that the pyrometer would read low. When the idea was tried, it was found that the error was small. Calculation showed that the success of the method depended on the high efficiency of the coolest radiation shield. Radiant-heat transfer falls off abruptly at low temperatures. In an open-hearth-furnace uptake the water-cooled radiation shield may be as accurate as the same shield when exposed to the radiation from the hot walls.

The error of the pyrometer with the water-cooled radiation shield (Fig. 9) is about 25F° at 2000°F and perhaps 50F° at 2400°F. This accuracy could, of course, be im-

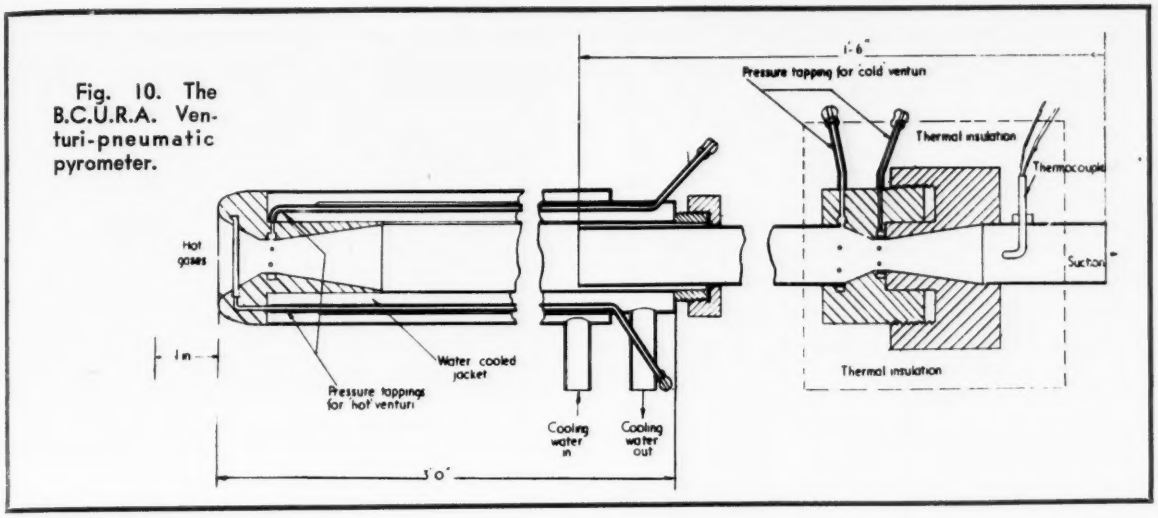

Fig. 10. The B.C.U.R.A. Venturi-pneumatic pyrometer.

proved by using extra radiation shields. It has been considered adequate for practical purposes.

The "method of half velocity" is perfectly satisfactory for testing pyrometers with a water-cooled radiation shield. It is unnecessary to turn off the suction completely as part of the test. The gas velocity is simply reduced to half of its maximum value. The drop in temperature is equal to the error of the pyrometer at full gas flow.

Applications of B.I.S.R.A. Shields

B.I.S.R.A. water-cooled radiation shields have proved their accuracy. At the Abbey Works of the Steel Company of Wales, two suction pyrometers were fitted to the air uptakes of an oil-fired open-hearth furnace. Pneumatic valves, actuated by the reversing levers, were attached to the air supplies for the ejectors. In this way only preheated air was aspirated, not waste gas. The tests lasted for ten days. By the end of the test the pyrometers were running continuously, night and day, for two or three days without needing any attention.

Several practical conclusions were drawn from these tests. First, the necessary services must be well engineered; air and water supplies at adequate pressures must be supplied at the right places. It is an advantage if the uptake can be plated, with a hole of the correct size fitted at the right location. Plate and hole might even be water cooled. Such an arrangement is infinitely better than plugging holes with brick-ends and cement. The pneumatic valves must be fitted and must close completely. These elementary things are often overlooked.

The pyrometer must be located in the correct place. It was introduced from the pit side. A large improvement in life resulted if the exposed end of the radiation shield was placed where it could not be sprayed with slag particles coming through the port during the waste gas period. The pyrometer should face somewhat downstream for this reason. The best position will depend on the furnace design.

At first, the compressed air was turned on as soon as the furnace reversed. This results in a lot of waste gas being sucked down the pyrometer. The life of the radiation shields can be doubled by delaying the process of switching on the ejector for one minute after reversal. This allows time for the waste gases to be swept away by the preheated air.

It is wise to meter the gas flow. Measuring the air pressure supplied to the ejector, or the suction at the cold end of the pyrometer, is not sufficient as the suction gives no warning if the pyrometer should become blocked. A Venturi and simple manometer are essential.

Later experiments have shown that the temperature of the air leaving the pyrometer is a useful guide to the volume of gas passing. A thermocouple in the outgoing gas can be connected to the temperature recorder and will indicate a sudden drop in temperature if the pyrometer blocks up. In any case, the Venturi is essential to establish the hot-gas velocity through the radiation shield. This must be calculated from the cross-section of the apertures in the shield, the mass flow of gas, and its temperature. A velocity between 500 and 700 ft/sec should be used.

With careful location, the pyrometer might run continuously for a week without attention.

The Problem of Pulverized Fuel

The products of combustion of pulverized fuel (coal) present special problems. The ash in the gas readily blocks the pyrometer. The effect of the deposition of ash has been found to vary with temperature. Below about 1800°F the dust is dry and passes through the shield system without causing much trouble. Above about 2500°F the ash becomes molten, and flows as a liquid over the shields. On cooling, a black coating is formed, looking like black enamel.

Between 1800° and 2500°F a bulky "birdnesting" deposit is formed. This consists of ash deposits adhering loosely at low temperatures and becoming more dense as the temperature rises.

Temperature measurement in the "birdnesting" region is difficult. The best solution that was found is the use of solid-zircon radiation shields with a few large holes. Such shields rely on low thermal conductivity to reduce the radiant heat loss. Their efficiency is only of the order of 80% and they are rather slow in their response. But they will operate in pulverized-fuel furnaces for an hour at a time.

Another method of measuring gas temperatures under these difficult conditions is the "Venturi-pneumatic" pyrometer described next.

The B.C.U.R.A. Venturi-Pneumatic Pyrometer

Although gas thermometers are rarely used in industry, a new form of dynamic gas thermometer presently is being tried. Such instruments use as the working fluid the hot gas which is to be measured. They have been called pneumatic pyrometers.

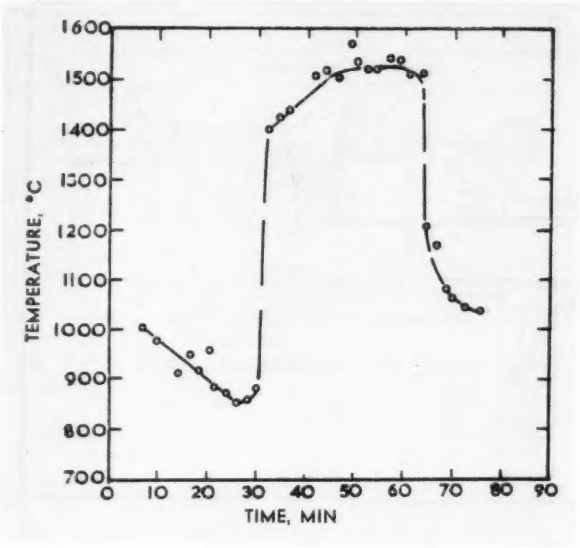

Fig. 11. Curve obtained for the pre-heated air and the waste gases in the uptake of a glass tank, using the B.C.U.R.A. Venturi-pneumatic pyrometer.

The principle of the pneumatic pyrometer has been described by Moore[9]. The hot gas is drawn through two orifices and is cooled as it passes between them; the temperature of the gas is measured at the cool orifice. The differential pressures across the two orifices are also measured, and the ratio of the densities of the hot and cool gas is deduced from the ratio of the pressure differences. This ratio is equal to the ratio of the absolute temperatures of the hot and the cool gas. Hence, if the pressure differences are Δp_1, and Δp_2, and the temperatures of the hot and the cool gas are T_1 and T_2, respectively,

$$T_1 = KT_2 \, \Delta p_1 / \Delta p_2$$

where K is a factor which should not vary greatly with temperature. The instrument is, in effect, a constant-pressure gas thermometer.

The British Coal Utilization Research Association (B.C.U.R.A.) has developed a pneumatic pyrometer in which the orifices are replaced by Venturis (Fig. 10). This has two advantages: (1) The surfaces do not collect dust and ash as orifices do, and the calibration is not so much affected by any dust which does adhere. The pyrometer, therefore, can be used in dirty gases for considerable periods without attention. (2) The value of the near-constant K does not vary appreciably with temperature or flow rate.

The freedom from the effect of dust collection makes this pyrometer a practical industrial instrument. The constancy of K enables the pyrometer to be calibrated at room temperature. A small correction is necessary for the cooling of the gas in the short length of converging tube before the front Venturi throat.

The pyrometer is of simple construction but the measurement is slightly complex. Three measurements are necessary. The *temperature* at the cold end must be multiplied by the *ratio of the pressure differences* across the Venturis. An electrical method of making this calculation instantaneously is now being tested. Moore used the alternate method of keeping one pressure difference constant and correcting mechanically for small changes in the exit temperature.

The advantages of this pyrometer are great speed, almost unlimited temperature range, simplicity, and ro-

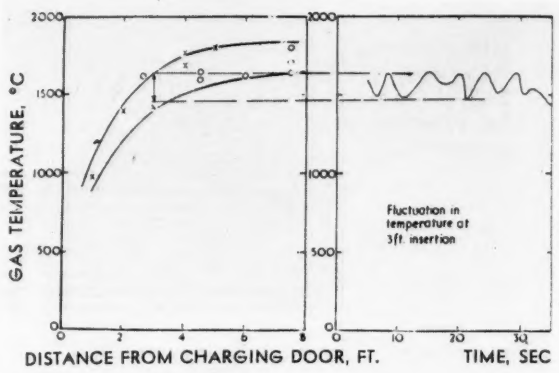

Fig. 12. Traverses across a producer-gas-fired open hearth furnace using B.C.U.R.A. Venturi-pneumatic pyrometer.

bustness. At present, it is only in its experimental stage and an accuracy of only 5% has been claimed. However a large part of this uncertainty lies in the instrumentation which has not yet been taken beyond the stage of simple manometers to measure pressure differences.

An example of its application has been given by Goodridge, Jackson and Thurlow[10]. The Venturi-pneumatic pyrometer was used to measure the temperature of both the preheated air and the waste gases in the uptake of a glass tank. A typical temperature record is shown in Fig. 11. The same instrument has been used to measure flame temperatures in a producer-gas-fired open-hearth furnace. The pyrometer recorded rapidly fluctuating temperatures shown in Fig. 12.

It is, perhaps, too early to assess the full potentialities of this pyrometer.

Conclusions

Gas temperatures now can be measured with confidence. Suction pyrometers are commercially available which will give known accuracy and reasonable life. New methods of testing accuracy during operation enable the operator to rely on his readings. There is room for improvements in speed, simplicity and extended temperature range.

Acknowledgments

The work reported has largely been a cooperative enterprise between the author's company, Land Pyrometers Ltd., the British Iron and Steel Research Association and the British Coal Utilization Research association. The author is glad to record his indebtedness to his colleague Mr. R. Barber, to Dr. R. Jackson of B.C.U.R.A. and his staff, and to Mr. R. Mayorcas and his colleagues at B.I.S.R.A. The work on the Venturi-pneumatic pyrometer has been carried out solely by B.C.U.R.A.

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Fig. 1. Main panel shows temperature recording controllers.

Fig. 2. The entire length of the Continuous Galvanizing line can be controlled from this one point.

Continuous Galvanizing

JONES & LAUGHLIN Steel Corp. recently showed the press its new continuous hot-dip galvanizing line at its Pittsburgh Works.

The $6¼-million installation which went into operation at the beginning of this year has a capacity of 7000 to 8000 tons per month.

Sheets from 14 to 30 ga. in width from 20″ to 48″ can be galvanized and coiled onto a reel, weighing some 6 tons, with a maximum speed of 300/ft min. The process follows in general the Sendzimir patents controlled by Armco Steel Corp.

The picture of a scale model (Fig. 3) shows how the sheet moves on the 600-ft line. The following major units have instruments and controls: (1) A 20-ft oxidizing furnace, to remove lubricants and other combustible material; (2) a 104 ft reducing furnace where the strip is annealed; (3) a 224 ft cooling furnace (both these furnaces use dissociated anhydrous ammonia); (4) a flux-free molten zinc bath (coating unit) where wetting and bonding occur instantaneously; (5) dissociators, chemical treatment tanks and roll preheat pot.

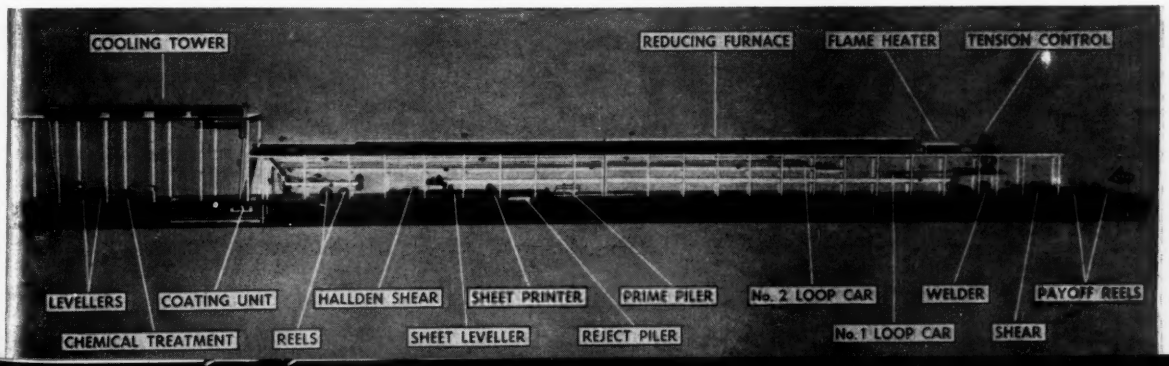
Temperature in all units is automatically recorded and controlled. Fig. 1 shows part of the main panel board, where 16 Leeds & Northrup temperature recording controllers are mounted. In the upper row (l. to r.) is shown one of the 6 cooling-section controllers (with thermocouple actuation); the five other units control temperatures in the five zones of the reducing furnace. The measuring units are Rayotubes. In the bottom row (l. to r.) another recorder controller of the cooling furnace is followed by 5 excess-temperature recorders for the reducing furnace. Each of the excess-temperature recorders is equipped with an alarm.

A checking recorder allows manual checking of each zone by a 16-point selector switch calling in the signals from thermocouples. The same arrangement also allows checking the temperatures in the cooling furnace over separate thermocouple circuits.

Dissociators have temperature indicating controllers and an excess temperature indicating controller; chemical treatment tank has a temperature recording controller. and temperature in the Roll Preheat Pot (used to preheat the coating rolls) is also recorded and controlled. Actuation is from thermocouples; control throughout the plant is pneumatic.

General Electric Company furnished all the drive and control equipment. An operator at a central location has the whole line under control (Fig. 2) and can instruct line personnel over a two-way intercom set.

Fig. 3. A scale model of Jones & Laughlin Steel Corporation's new Continuous Galvanizing line.



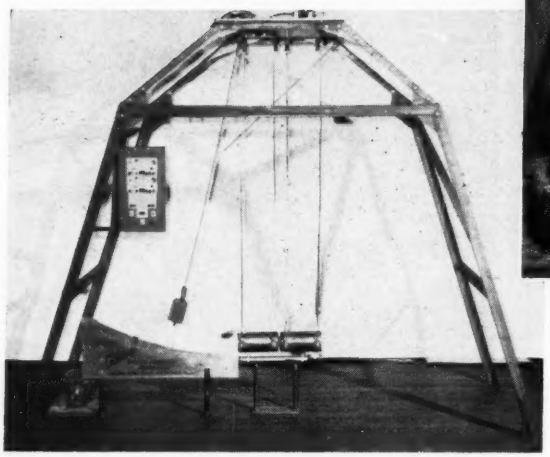


Fig. 1. Typical ballistic pendulum comprises shock receiving pendulum (right), shocking pendulum, and automatic release unit (left).

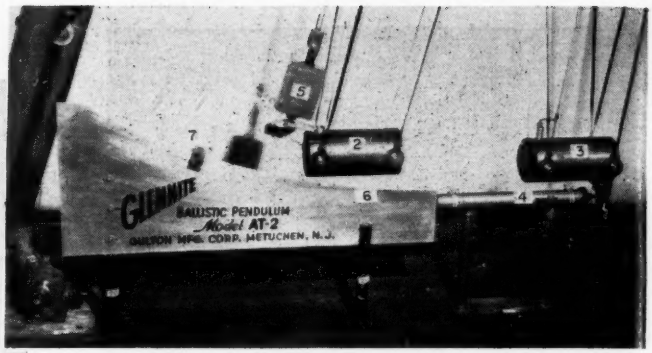


Fig. 2. Close-up of ballistic pendulum, showing receiving pendulum (3) engaging pneumatic-type shock restrainer (4); automatic release unit (5) for shock pendulum (2); scale (6) for setting release point; and switch trigger (7) for releasing pendulum automatically.

Accelerometer Calibration by

Of the six basic methods for accelerometer calibration, the ballistic pendulum provides vector (impact) test acceleration forces up to 500 g with the highest accuracy. Procedures, techniques, and variables are described for use of the ballistic pendulum, including details of calibration check and recording.

ALVIN B. KAUFMAN
Arnoux Corporation

VIBRATION is an important industrial condition. Control of some industrial machinery depends on the level of allowable vibration in process equipment; in other installations it is essential to determine the level of vibration to improve structure design or to prevent structural failure, as in aircraft or missiles. For these applications the calibration of the measurement accelerometer at the low-level *g* forces available with an electrodynamic shaker may be insufficient. In order to exceed the 30-55 maximum *g* calibration acceleration available with the electrodynamic shaker, it is necessary to employ the ballistic pendulum.

A review of accelerometer calibration equipment, including equipment limitations, is essential in determining when the ballistic pendulum should be used.

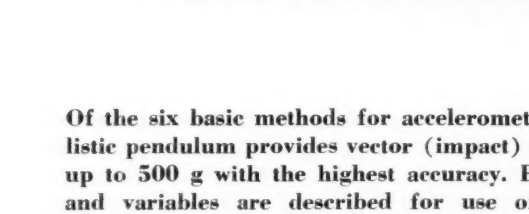


Fig. 3. Pulse-time characteristic of AT-2 ballistic pendulum. Pulse has duration of about 1 ms.

Methods of Calibrating Accelerometers

The six methods of accelerometer calibration[1] are (1) centrifuge, (2) electrodynamic shaker, (3) resonant beam, (4) piezoelectric shaker, (5) oscillatory pendulum and (6) ballistic pendulum.

Centrifuges are in general use for the calibration of accelerometers indicating steady-state acceleration. However, where dynamic calibration is required or where the accelerometer is of the velocity or self-generating crystal type, a vibratory force must be used for calibration.

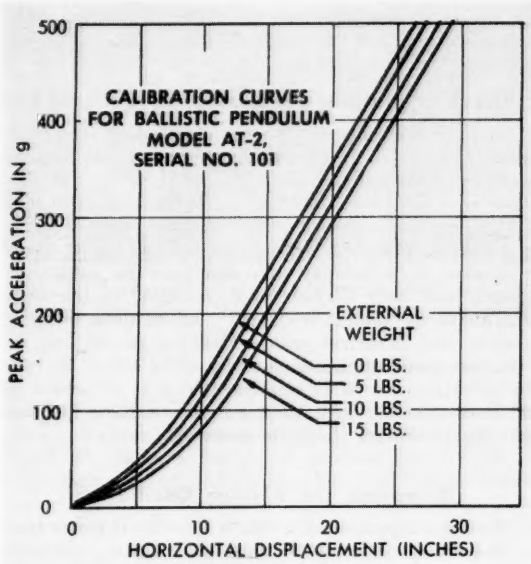
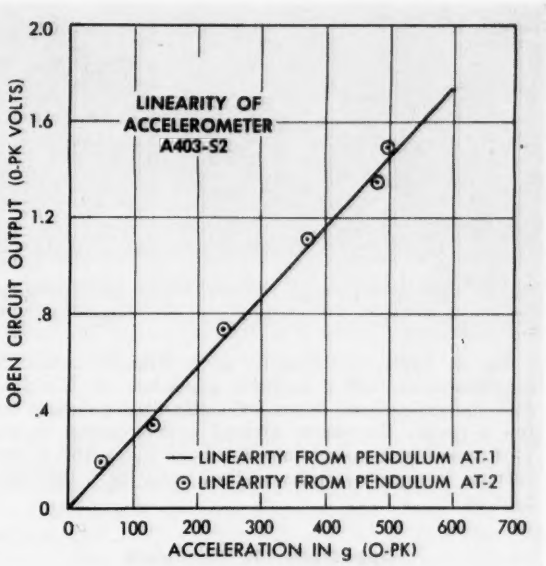


Fig. 4. Vendor-supplied calibration curves show peak acceleration vs horizontal displacement for various external weights hung on the receiving pendulum. Linearity is shown in terms of volts vs g (zero-to-peak amplitudes).



Ballistic Pendulum

Electrodynamic shakers are in general use for dynamic accelerometer calibration; these supply a sinusoidal forcing function. While this is desirable, unfortunately this class of shaker does not produce high *g* forces. Present limitations are 30-55 *g* over a frequency range of 20-5000 cps.

Resonant beams excited by an electrodynamic shaker can be employed to secure forces up to several thousand g's at discrete selected frequencies[2]. In general, low frequencies must be employed to prevent improper mode of oscillation and to obtain reasonable beam size. This method of dynamic calibration is limited by the accuracy of the measurement of beam-movement amplitude. Transverse or angular beam-developed *g* force (as related to the transverse/angular sensitivity of the accelerometer under calibration) is one important parameter.

The reciprocity method of calibration at high *g* forces involves numerous parameters, some difficult to evaluate, and is not in general use because of limitations in accuracy and available techniques[6]. Moreover, it is applicable only to certain classes of tranducers.

Piezoelectric shakers are usable up to high frequencies, but again are limited to approximately 50 *g* maximum acceleration force.

Oscillatory pendulums (also known as "free swinging") have been discussed in the literature for the calibration of angular and linear accelerometers[3]. These pendulums, however, produce low accelerations and offer little over other conventional calibration methods.

Ballistic pendulums secure high acceleration forces in the range of 10 to 500 *g*. A moving pendulum mass is used to strike another pendulum and impart its energy thereto. This results in a transient shock pulse. Typical of commercial equipment is the Model AT-2 unit of the Gulton Manufacturing Company, shown in Figs. 1 and 2.

Features of the Ballistic Pendulum

The Ballistic Pendulum offers a high *g* acceleration calibration capable of reasonable accuracy with a minimum of critical test parameters[6]. For the purpose of illustration, the Gulton AT-2 pendulum, with which the author has had experience, will be used to indicate the procedures, methods, and parameters in calibration work.

The AT-2 produces approximately a half-sine-wave, clean shock pulse of one-millisecond duration, as seen in Fig. 3. Thus the pulse effectively has a frequency of 500 cps, and a repetition rate controlled by the speed at which the shocking pendulum is raised and released. The rep rate is low, but because of the method of calibration this is inconsequential.

Test loads up to 15 pounds may be used without introducing calibration error, if the proper calibration curve is used. Fig. 4 shows the calibration curves (peak acceleration vs horizontal displacement) for various external weights attached to the receiving pendulum.

The AT-2 contains a built-in standard calibration accelerometer to supplement the vendor-furnished operational calibration curve, which has a specified accuracy of ±10%.

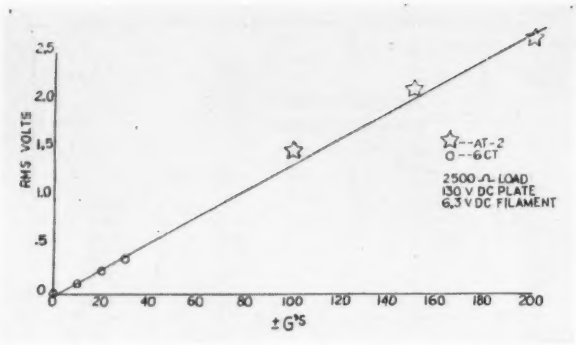


Fig. 5. Typical calibration of a Glennite A501CM accelerometer with a ballistic pendulum. A Calidyne 6CT shaker was used to secure calibration points in the low g range. The vector secured accelerometer output (with pendulum calibration) has been converted to rms voltage to agree with the method used for shaker calibration.

Operating the Pendulum

Pendulum operation can be manual or automatic. According to the desired *g*-force range, spring number one or two is fastened to the impact face of the shock receiving pendulum (element no. 3 in Fig. 2). This is determined from the pendulum calibration curves. These same curves indicate in inches how high the shock pendulum must be raised and released to produce the desired impact acceleration in the receiver pendulum. The shocking pendulum can be raised and released manually or automatically. For automatic operation an electric trip switch is positioned along the scale and an electric motor raises and releases the shocking pendulum.

Pendulum Calibration

Calibration of the ballistic pendulum, to secure greater accuracy or to verify the vendor-supplied curves, can be accomplished by several methods. Utilizing the vendor-supplied internal accelerometer curve, its output (g_p/E_p)* may be compared with the *g* vs pendulum displacement curve. However, this method is not completely independent and, in the writer's opinion, should be supplemented by the following method.

An accelerometer with a natural frequency of at least 5 kc should be calibrated on a centrifuge, an electrodynamic shaker or a crystal shaker with the best available technique. Unfortunately, accelerometers with this high a natural frequency are usually of the vibratory type (i.e., barium titanate), not capable of precise calibration on a centrifuge. Absolute *g*-force accelerometers have comparatively low natural frequency (f_n) as compared with vibratory or crystal accelerometers. Therefore, a shaker must be used. As calibration with such a device is limited to about 50 *g*, the curve must be extrapolated, and extreme care in calibration must be used to secure reliable results. An extrapolated curve is shown in Fig. 5; note that it should go through the X-Y axis origin.

This calibrated accelerometer is then installed and used as if it were an accelerometer "to be calibrated" and its volts/*g* output correlated against the vendor curves. Certain corrections must be made to this accelerometer calibration curve to make it applicable to the ballistic pendulum. These corrections are associated with four parameters: (1) shock frequency of the pendulum, (2) natural frequency (f_n) and damping factor (h) of the accelerometer, (3) operational configuration of the accelerometer, and (4) recording medium.

*g_p means peak *g* force; E_p means peak emf output.

Effect of Natural Frequency on Calibration

The shock frequency of the pendulum is approximately 500 cps. Certain considerations indicate that only accelerometers with a much higher f_n than the shock frequency of the pendulum can be calibrated thereon. This is because a seismic-type vibration pickup responds as an *accelerometer* in the region well below its natural frequency, as a *velocity indicator* near its natural frequency, and as a *displacement indicator* in the region well above its natural frequency[4]. All of these terms are relative, and an instrument specified for one of these uses often has useful applications under other labels. However, the accelerometer to be calibrated, if it is to behave like an accelerometer, must have a higher natural frequency than the pendulum shock frequency.

Removing the Ringing Oscillation

The second parameter is that a "shocked" or transient excited accelerometer will "ring," or oscillate, at its own resonant frequency[5]. This means that if the output of the accelerometer undergoing test is observed, a multitude of waveforms will be seen at time of shock. These waveforms will consist of the basic 500-cps ballistic impulse combined with the "ringing" output of the accelerometer. This is shown at the left in Fig. 6. The extent of the "ringing" is, of course, a function of the accelerometer damping. However, to allow observation and recording of the pendulum-induced shock only, the accelerometer output voltage must be fed through a low-pass filter to the recording or calibration-indicating device. Fig. 6 indicates the effect of such filters on the calibration pattern. With oscillograph recording the low-pass filter may not be required, as discussed later.

Effect of Accelerometer Damping on Calibration

The *damping* of the accelerometer may be an important factor in another way. With a *sinusoidal forcing function* well below the f_n of the accelerometer, unity signal output is produced regardless of the damping of the accelerometer. However, as shown by Fig. 7, if the forcing function is a transient, great over-shoot of accelerometer output may occur with low values of h. Normally the ballistic pendulum is considered to produce a sinusoidal shock pulse. However, it can be seen that if it produces a quasi-transient function, correction of the accelerometer output signal level is required—*if* it has low h and/or is to be used for measuring sinusoidal vibration. The measurement of accelerometer damping factor (h) is discussed in reference 5.

If the accelerometer is to be used for measurement of "shock," such as in ballistic missiles, it can be seen that the ballistic pendulum is superior to shaker calibration as it subjects the accelerometer to the same conditions as generally encountered in operational use. In this instance the h of the accelerometer is not a calibration parameter.

Effect of Filter on Calibration

It is necessary, as indicated, that the accelerometer output be fed through a low-pass filter. The filter affects the calibration in three ways, depending on: (1) the selected cutoff frequency, (2) the degree of cutoff slope and attenuation, and (3) the insertion loss of the filter.

The filter roll-off frequency must be selected to start cut-off *well above* the nominal pendulum frequency, and

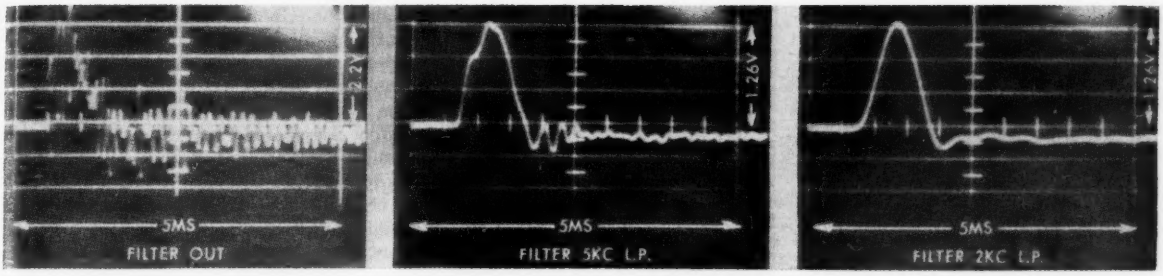


Fig. 6. Low-pass filter can remove high-frequency "ringing" oscillations due to natural frequency of the shock-excited accelerometer, passing only the impulse due to the ballistic shock.

well below the accelerometer f_n. At the filter cutoff frequency, standard practice specifies that the signal be down 6 db (voltage-wise); and, as a flat response should be maintained to at least 600 cps, the filter roll off should be specified for at least 1,000 cps. The vendor of the AT-2 supplies a 2-kc filter, but other values may be secured on request.

The *degree of filter attenuation* per octave should be specified as Gaussian, or that value at which the filter itself will not ring with application of a transient signal. The total required attenuation of the filter is subject to several variables (e.g., f_n and h of accelerometer) but 40 to 60 db is usually satisfactory.

The *insertion loss* of the filter is a very important parameter. The recorded accelerometer signal does not represent its actual output voltage—with one exception: If the calibration test filter is identical to and also used in the operating circuit configuration no correction factor need be employed. However, in most operational uses the accelerometer output is recorded directly without a filter. The filter is required in testing of airframes, etc., only if (1) the recording equipment goes up to the accelerometer f_n range or (2) transient rather than forcing vibration is encountered.

Filter impedance is another factor. In using a low-pass filter, it is generally necessary that the input and output loads approximate the filter impedance. Design of the specific filter modifies this rule and variations are encountered. Also, the input and load impedances may be varied at will, provided that filter attenuation and roll-off frequency changes are acceptable. Gulton specifies that the 2-kc filter supplied with the AT-2 ballistic pendulum work from a signal source less than 125 ohms and into a load of approximately 31,000 ohms. However, the output wave form (of a Glennite A501CM accelerometer) in which the source impedance (cathode-follower output) was 500 ohms, and the filter load was maintained as specified, showed no detrimental effects. High-impedance accelerometers should be operated through their associated amplifiers or the test unit supplied with the AT-2. If the test amplifiers are used, further correlation must be made by determining amplifier-filter gain so as to make correction to secure the actual accelerometer output.

Assuming the filter has no "a-c" losses in its bandpass frequency range, the *filter insertion loss* can be calculated as the percentage ratio of load resistance to the resistance measured at the input to the filter. It is desirable to introduce a 500-cps signal into the filter and measure its loaded output signal if highly accurate information is required. Note that the addition of the filter to the accelerometer can, by a loading action, lower its output and cause the data secured to be inaccurate. In general, the input impedance of the filter should exceed ten times the output impedance of the accelerometer amplifier.

Low-frequency Response of Equipment

An additional requirement is that the measurement equipment must have good low-frequency response; otherwise the measured accelerometer output under ballistic shock will be lower than actually exists. For this reason, the low-frequency response of oscilloscope, accelerometers with internal amplifier, cathode-follower amplifiers, etc., must be examined closely.

A shock pulse 1-millisecond long, when integrated, results in a step which rises to a peak in one millisecond. In order to record accurately the height of this step, it is necessary to have circuitry in which there is no appreciable loss in amplitude over that time. It is readily shown that a first-order system, such as a capacitor delivering its output into a resistive load, loses a fraction of the step amplitude equal to the ratio of the length of a square pulse to the time constant of the system. On the assumption that a loss of amplitude of 2% is allowed, the time constant must be fifty times the pulse length or, in the present case, 50 milliseconds. The corresponding frequency response is readily computed (the system is 3 db down at 3 cps). For a triangular pulse, the requirement is half as stringent, so that 3-db response down to 6 cps is required. The half-sine pulse is intermediate between these cases.

It should be possible to get agreement within 10%, or perhaps better, between shock and sinusoidal calibrations of a good piezoelectric accelerometer under conditions where the frequency-response requirements are met and the cathode follower is not overloaded[7].

Recording Factors

The actual method of calibration should be coordinated with the field use of the accelerometer—that is, whether the voltage output is to be used with an oscilloscope or tape recorder, or whether its output current is to be recorded on an oscillograph.

Where the accelerometer output *voltage* is to be recorded, a Polaroid camera/oscilloscope method can be employed. The accelerometer is mounted on the shock receiving pendulum, and supplied with excitation power as required. Assuming a combination accelerometer-amplifier-cathode follower unit (such as the Glennite A500 series), plate-filament voltages are applied. The output is connected to the low-pass filter and its output to the oscilloscope. The scope gain and sweep are adjusted so that satisfactory amplitude and pulse widths are observed with operation of the pendulum at a selected *g* force. The scope gain is then slightly adjusted, as required, so that the Y axis divisions represent known voltages. As internal scope calibrators have, for this use,

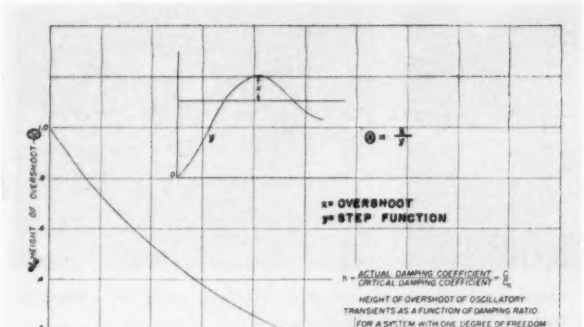

x = OVERSHOOT
y = STEP FUNCTION
h = ACTUAL DAMPING COEFFICIENT / CRITICAL DAMPING COEFFICIENT
HEIGHT OF OVERSHOOT OF OSCILLATORY TRANSIENTS AS A FUNCTION OF DAMPING RATIO FOR A SYSTEM WITH ONE DEGREE OF FREEDOM
HEIGHT OF OVERSHOOT
DAMPING RATIO — h
FIG. 1

Fig. 7. Effect of accelerometer damping (h) on overshoot caused by transient shock excitation. Y is amplitude of applied step-function; X is overshoot; ratio of X/Y is plotted against h.

poor accuracy (generally 5 to 10%), external calibrating equipment is preferable. The calibration should be verified by a 1% meter and a-c signal.

Note that the pendulum produces a single amplitude (SA* or vector) g-force pulse. The resultant scope pulse is also peak or SA. The scope calibrator, although putting out a peak-to-peak signal, allows proper calibration without a correction factor if one end of the pattern is referenced to the scope zero base line.

The scope-camera must be synchronized with the impact-produced signal. Several methods can be used. The camera shutter can be opened just prior to impact, by visual observation, and closed immediately thereafter. Alternately, the scope sweep can be triggered by (1) the oscilloscope internal amplifier and leading edge of shock pulse, (2) the external pendulum-operated switch, or (3) manually.

Interpreting the Record

Intrepretation of the film record involves several parameters. The resultant scope pattern represents a peak (SA or vector) voltage and g force. These must be changed to peak-to-peak volts and double-amplitude (DA) g by multiplying the known g force and the photographic record voltage by a factor of two. Next, the voltage figures must be corrected for the insertion loss of the filter. If the filter has a 6-db (50%) insertion loss, the voltage figures are again multiplied by two. These DA g forces and peak-to-peak volts can then be reduced to rms values or to other forms as required.

An additional parameter that must be considered carefully is the response of the oscilloscope to transient waveforms. In many oscilloscopes overshoot of 4 to 10% is common. The pendulum-produced accelerometer signal can be considered quasi-transient, and thus some correction for trace overshoot may be required. It is advisable to consult the scope manual for oscilloscope performance in regard to this parameter. Square-wave techniques to observe overshoot can be employed to advantage provided that the test frequency used is high enough not to confuse overshoot with low-frequency roll-off.

The accelerometer calibration data can then be used to calibrate the recording equipment. The peak-to-peak voltages or their rms equivalents are then supplied into the operational tape recorder from a signal generator in order to correlate the recorder characteristics, and to determine system output (volts/g). These voltages are applied at selected frequencies to secure a family of curves to indicate both voltage and frequency linearity of the recording equipment. A system calibration of volts vs g's may then be plotted. Fig. 8 shows these operations for the oscillograph system.

Subsequent test data voltages can then be reduced directly to g values, record frequency noted, and g value corrected for frequency response as required.

Use of Oscillograph

Where the accelerometer output current is to be used (e.g., cathode follower assembly) it is preferable to record directly into the galvanometer and oscillograph to be used operationally. It must be remembered that the data thus obtained represent vector g's and inches. Both must be doubled for a calibration plot of DA g and peak-to-peak inches of deflection.

In the use of an oscillograph it is important that certain parameters be recognized. Galvanometer sensitivity will vary from unit to unit, with changes of block magnetic structures and their loading with dummies or other galvanometers. These parameters can produce up to 20% variation in sensitivity.

The use of a low-pass filter is not always essential when recording into a galvanometer. If the galvanometer (such as C.E.C. 7-323) has an f_n of 1000 cps and its h is 0.64, it has a flat frequency response up to approximately 600 cps. This allows recording of the shock-induced frequency and voltage output of the accelerometer, while effectively attenuating the higher frequency "ringing" output[5] of the accelerometer. Thus the galvanometer acts effectively as the low-pass filter required with voltage calibrations.

However, if it happens that the f_n of the accelerometer is close to the galvanometer f_n, or if the "ringing" output is high in amplitude, sufficient attenuation may not exist to eliminate the need for the low-pass filter.

Another important parameter that cannot be overlooked is that a galvanometer with 0.64 damping produces a 4 to 10% overshoot when excited by a step (or transient) function, as shown in Fig. 7. As the accelerometer signal using a ballistic pendulum is quasi-transient, the pendulum calibration recordings may indicate a sensitivity or calibration curve somewhat higher than that indicated by sinusoidal electrodynamic calibration. If operational use is with sinusoidal vibration rather than transient shock, it will be necessary to make a correction to operational recorded data.

Oscillograph Calibration Techniques

Specific accelerometer oscillograph calibration technique is as follows: The accelerometer output is connected into a galvanometer. Proper circuit configuration should be used so that proper galvanometer damping resistance is secured. The galvanometer flat frequency response should extend to at least 500 cps, but not any higher above this than necessary. The accelerometer is then shocked at desired g accelerations, and recordings are taken, as in Fig. 9. The recordings are then reduced to peak g's and peak inches. Multiply by two to secure DA g's and peak-to-peak inches, tabulate, and graph (Fig. 8a).

This is all that is required to secure satisfactory recordings. A recording speed of approximately 2½ inches per second is satisfactory. Maximum galvanometer lamp

* Peak-to-peak amplitude of a sinusoidal signal is referred to as a double-amplitude (DA) signal. The vector representing the signal would have half of this amplitude and is therefore referred to as single-amplitude (SA) or vector amplitude.

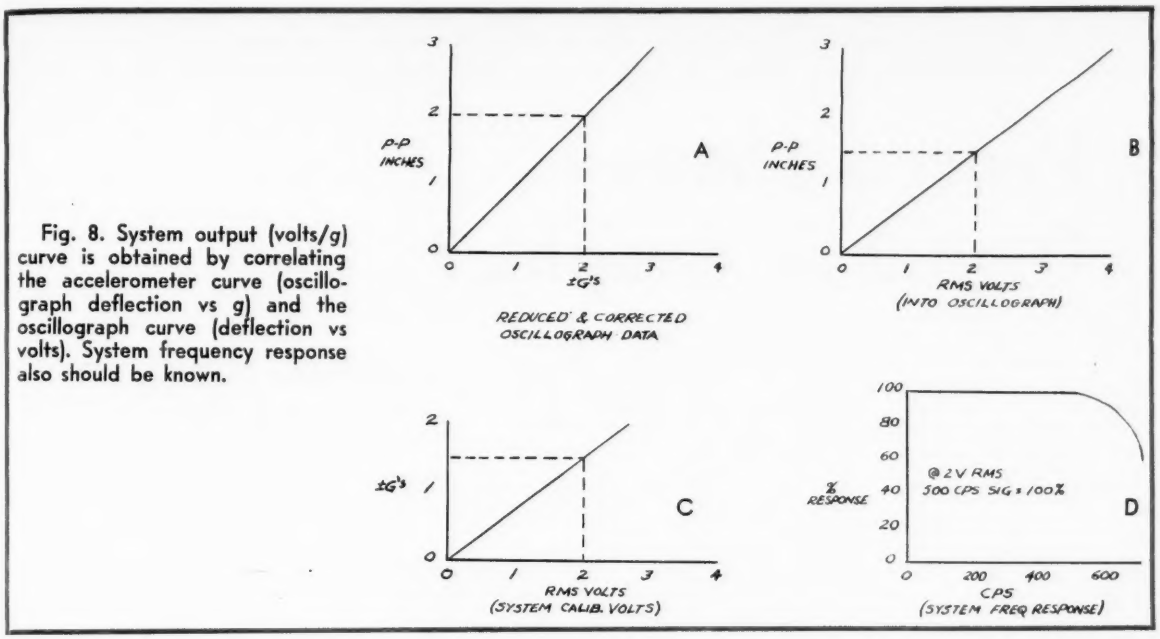


Fig. 8. System output (volts/g) curve is obtained by correlating the accelerometer curve (oscillograph deflection vs g) and the oscillograph curve (deflection vs volts). System frequency response also should be known.

voltage is required regardless of the recording medium, with the typical oscillograph. Fig. 9 indicates a typical recording (slightly retouched) made with a Consolidated oscillograph, 7-323 galvanometer, and 1127 paper. Orthopan film gives comparable results, with somewhat greater resolution of trace. Timing lines are generally not used to prevent loss of the light-density recording trace at the peak of the signal.

If the accelerometer uses an external cathode-follower amplifier, low-pass filter, or galvanometer in which either a different circuit configuration or similar but different parts are to be employed at a test facility, an additional calibration step is necessary: In this case a signal generator is substituted for the accelerometer and selected rms voltage applied at discrete frequencies. This additional record is reduced and plotted as rms volts vs p-p inches of deflection (Fig. 8b). Correlation between the two graphs now allows a new curve to be plotted—rms volts vs g (Fig. 8c). The rms volts from this curve are then applied to the operational recording system and a new plot made, from reduced records, of system's g vs p-p inches.

The above noted parameters apply to ballistic-pendulum calibrations. However, the procedures and methods outlined can vary with calibration components. In all cases, however, it is necessary to maintain or reproduce all test parameters to operational parameters in order to secure accurate calibration. Factors of importance are: galvanometer damping, consistent loading, frequency response, uniform component characteristics, etc.

It is advisable to substantiate the ballistic-pendulum calibration by support calibration with other independent equipment. Note on Fig. 5 that three shaker calibration points were secured in the lower range to verify the HP calibration points.

Many variations in calibration technique can be employed, but if the test parameters outlined are followed, satisfactory calibrations can be secured.

Accelerometer calibration accuracy of ±5 to 10% can be secured reliably. System calibration, data reduction errors, etc., can allow a responsible engineer to quote over-all operationally reduced data as having maximum errors of ±10 to 15%. These figures in general are pessimistic, nominal error being ±8%.

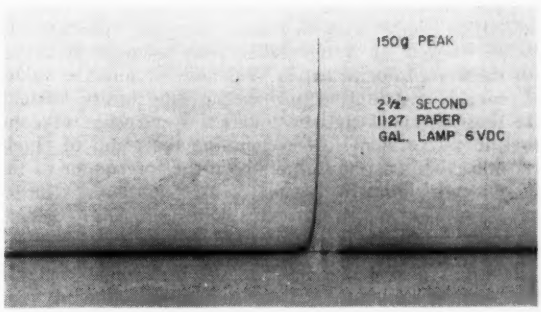


Fig. 9. Typical oscillograph calibration of an accelerometer incorporating an internal cathode follower.

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Process Data— Digital or Graphic?

NATHANIEL BREWER
Fischer & Porter Company

DIGITAL RECORDING was coincident with the advent of man upon our planet. However, it was only about two generations ago when engineers got in the habit of presenting data in the form of graphs. The obvious value of these graphs in predicting trends motivated engineers to develop instruments for automatically recording such trends.

Quite separately and for entirely different reasons, LeClair of Commonwealth Edison Company (Chicago) in 1938* hooked up a typewriter with solenoid actuators for the keys, to print out in rows and columns the values of energy distribution throughout the utility system. He thus obtained statistical data for purposes of comparison rather than for determining the trend of single variables. This seems to have been the forerunner of the present-day automatic logger.

Digital vs Graphic Display

It seems almost axiomatic to the instrument designer that there is no value in presenting rapidly moving variables on an indicator designed for digital readout. However, if the pointer on a circular dial indicator is moving, we can quickly grasp the significance of velocity or acceleration of the pointer tip. The human mind is quite well fitted to respond to analog data with amazing alacrity and precision, as exemplified in fast moving games such as ping-pong. Yet digital information is absorbed at a very slow rate indeed, averaging not much better than four information units or bits per second.

Nor is it likely to be disputed that slow moving data requiring a multiplicity of analog dials, such as displayed on domestic electric or gas meters, are more easily and more accurately read if presented in digital form on a drum-type counter. Likewise, recent developments in electronic measuring instruments find value in presenting measurements in digital form, especially when more than three significant figures are obtainable.

From this it becomes apparent that data become meaningful only when arranged in an orderly manner. In either indicated or recorded form random digital data bring utter confusion, and until we can visualize their relationship to some reference, we cannot even attempt to remember them. Likewise, it is seen that analog information, when presented on a group of dials with indicators pointing off in all directions, is confusing since each has its own reference point and each scale has a different digital value.

Don't we then come down to the fundamental basis for evaluating the two methods; namely, *recorded analog data best represent the wanderings of a single variable with respect to another, usually time*, in which case it furnishes us a time sequence of events, and the *digital presentation is best adapted to furnish us parallel information measured simultaneously*. Since the purpose of such information is comparison, digital data must be orderly arranged in rows and columns, the rows usually being time values and the columns the independent variables.

Reliability

Much has been said pro and con concerning the relative reliability of graphic and digital recorders. I think this can be resolved on the basis that the logger reliability may be stated in terms of the sum of its components whereas the graphic recorder is more likely to be as reliable as its one worst component, not the sum of all. This undoubtedly gives the graphic recorder the edge, but from a practical standpoint, when loggers are built with reliable telephone-type stepping switches and relays conservatively applied and with proper attention given to spark suppression, life expectancy for major components should be well over ten years. Temperature loggers are in use in the Atomic Energy Plant at Hanford reading out three temperatures per second, and have to date accumulated between 30,000,000 and 40,000,000 readings without replacement of a major component.

It would seem that the weakest link in the whole system is in the least expected source of trouble, the typewriters. They seem to show all of the vagaries of typewriters operated by human hands (heavy hands at that) such as keys jamming, carriage return failure, etc. But we have learned that much of this can be eliminated by paying careful attention to controlling the time sequence of the solenoid operators and by building into those solenoids some of the delicate touch of the graceful female hand.

Management's Viewpoint

The basic requirements of a good data system are to: (1) Measure. (2) Store information. (3) Provide basis for analysis. (4) Provide basis for decision.

*U. S. Patent 2,313,752

Abstracts from a talk presented at Recorder-Controller Section Meetings, SAMA, Hershey, Pa., May 8, 1956.

Obviously the graphic recorder measures and stores information. The digital recorder does these and further presents the data on a comparative basis at fixed time intervals with much of the data reduced to usable form by integration, averaging, or mathematical compensation, thus furnishing the basis for analysis and decision.

In addition to performing these functions, experience to date in the use of process data loggers shows the following advantages:

A. Direct Advantages
   1. Some labor saving in logging
   2. Reduced investment in control room size and equipment
   3. Cost data in a form suitable for business machine input
   4. Technical calculations made automatically for use as operating guides
B. Potential Advantages
   1. Possible increased yield (by data analysis)
   2. Data quickly available for Management decisions
C. Intangible Advantages
   1. Human errors are eliminated
   2. Operator free from routine functions and available for more useful functions
   3. Sequential records during emergencies are obtainable
   4. All points logged simultaneously (nearly)
   5. More technical data available by short time of logging for process characteristics.

Offsetting these advantages is the relatively high incremental cost of adding an automatic data logger on top of an existing or complete system of conventional instrumentation. While the cost of a logger ranges from $15 to $300 per point, plus a relatively fixed amount for the central equipment common to all points, potential savings in the over-all cost of instrumenting a process may be realized by dividing the total information input between the data logger and the conventional instruments on the basis of their respective merits. Additional operating experience with existing installations will rapidly bring the cost picture into clearer focus, with additional favorable changes in cost to be expected from standardization of components and other improvements in design.

The Future

It seems safe to say that the digital logger will be limited to use in centralized control points and, therefore, will never be competitive with field-mounted graphic recorders, nor is it likely to be competitive with central panels containing fewer than 30 records. Beyond that point it is likely to reduce the use of graphic recorders on large panels by 20% to 40%, depending somewhat upon our ability to develop additional computer memory techniques which so far have not been thus applied.

That the automatic digital data logger is an accepted and growing development in the field of instrumentation is no longer to be questioned—the big question now being how soon and how big. A recent conservative estimate by M. W. Kellogg Company stated that this infant industry, with little more than a year of successful operation to point to, will expand its sales in the "petroleum and petrochemical industries by 1960 to $8,000,000 of data loggers, compared to $21,000,000 for graphic recorders (assuming no displacement by automatic data loggers); and by 1965, $18,000,000 of digital loggers to $29,000,000 for graphic recorders." They further state "that future developments and integration of digital logging systems with computers will probably make these figures conservative. For example, the day of the fully automatic ammonia plant is not very far in the future." Thus we may expect the digital data logger to supplement the graphic recorder and extend the field of instrumentation to achieve not only the fully automated process, but also to become an essential tool of Management, furnishing yield and material balances, inventory and cost data essential to optimum operating efficiency.

Timing Marker Generator

LOREN E. BOLLINGER*

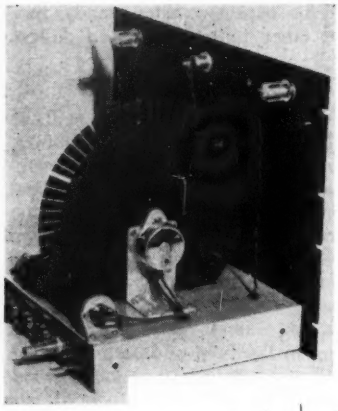
ROCKET-ENGINE research and development requires instrument readings from which the thrust, fuel and oxidizer flow rate, coolant flow rate, temperatures, chamber pressure, various control pressures, etc., can be derived. These data can be recorded by chart-type recorders, oscillographs, cameras, etc. All recorded information should be correlated by common time markers.

Standard timing signals can be obtained from tuning-fork circuits, crystal oscillators, line-frequency timers, correlation with WWV transmissions [1,2,3], and other sources. Experiments wherein transient signals are of interest require time-signal pulses separated by a millisecond or less. However, there are many tests where 1-second time signals are sufficient. The timing-signal generator described is of the latter type.

Specifically, the timer was used during evaluation tests of rocket-engine propellants; the duration of the rocket firings was of the order of one minute; approximately one-third of the run time was required to attain equilibrium of propellant flows, coolant temperature, chamber pressure, thrust, etc. Common time signals were transmitted to all recording instruments; signal pulses from the generator actuated small solenoid pens located on each of the pen-type recorders, thus placing time marks on the charts. A 35-mm movie camera photographed the instruments on the data panel; a flashing signal lamp on this panel showed up as a black dot on each film frame.

*Research Associate, Rocket Laboratory and the Department of Aeronautical Engineering, The Ohio State University, Columbus, Ohio.

This work was sponsored in part by the Wright Air Development Center, U. S. Air Force under contract with The Ohio State University Research Foundation.



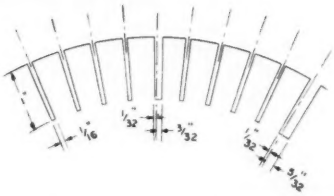


Fig. 1. Basic 1-second timing signals are obtained by milling 60 slots around disc that is rotated by 1-rpm synchronous motor. Slots permit light to fall on photocell in tube shown at lower left of chassis. Every fifth slot is double width, and every tenth triple width, to give the coded pattern of signals shown in Fig. 2. Center lines of slots are 6° apart.

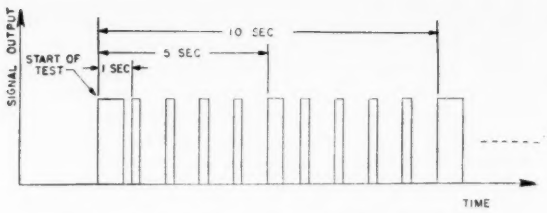


Fig. 2. Pattern of signals from photocell.

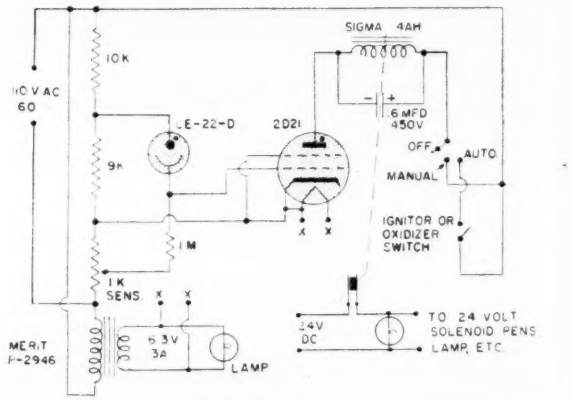


Fig. 3. Phototube-controlled thyratron circuit for energizing solenoid-operated time-marker pens. Thyratron fires when light falls on photocell. Capacitor across relay prevents it from opening when plate voltage swings negative on negative a-c cycle. Solenoid closes relay in 24-volt line to pens or lamps for making the timing signal.

Pulse Generator

The variable-pulse-width generator produces one pulse every second, with every 5-second and 10-second pulse coded by having longer durations. The timing device (Fig. 1) is composed of a metal disc, slotted along the periphery, and driven at a predetermined speed by a synchronous motor. The disc is interposed between a source of light and a photocell; appropriate slit systems were used on both the light source and on the tube to sharply define the beam of light.

Fig. 1 shows the disc configuration; sixty slots were uniformly milled along the periphery of a 10-inch aluminum disc. Each fifth slot was milled double width and every tenth slot had triple-width dimensions. This slot combination together with a one-revolution-per-minute electric motor gave rise to the output signal pattern shown in Fig. 2. It is seen that a large number of output signal variations can be secured by using various combinations of synchronous motor speeds and milled slots.

Electronic Timing Circuit

A schematic diagram of the electronic circuit used is shown in Fig. 3. A gas-filled CE-22-D phototube (similar to an RMA type 1P41 tube) was used as the light detector. Triggering of the normally non-conducting 2D21 thyratron tube by the output of the phototube occurred each time that a slot in the rotating disc became aligned between the slits of the phototube and exciter lamp housing.

An a-c voltage divider is used to supply power to the CE-22-D phototube and to the 2D21 thyratron. The use of a-c voltage obviates the need for plate current interruption of the thyratron because the grid recovers control each time the plate voltage goes negative. When light no longer reaches the phototube, the thyratron grid regains control during the next half-cycle of the plate-voltage supply; grid recovery causes the plate relays to be deenergized. Thyratron grid sensitivity was made adjustable through the use of a 1,000-ohm potentiometer in the voltage divider network. In practice, the sensitivity control was advanced until the thyratron tube fired consistently with the passage of each slot in the rotating disc, but below the point at which the tube fired continuously or erratically.

The output signal from the phototube drives the grid of the thyratron above the critical firing level and, as the grid voltage is in phase with the plate voltage, firing takes place. Thyratron conduction energizes a relay in the anode circuit, which in turn actuates the various solenoid pens and signal lamps.

The selector switch in the anode circuit of the thyratron provides either automatic or manual starting of time signal transmission. When on automatic, for example, the timing would start when the ignitor or oxidizer valve switch (for rocket propellants) was closed.

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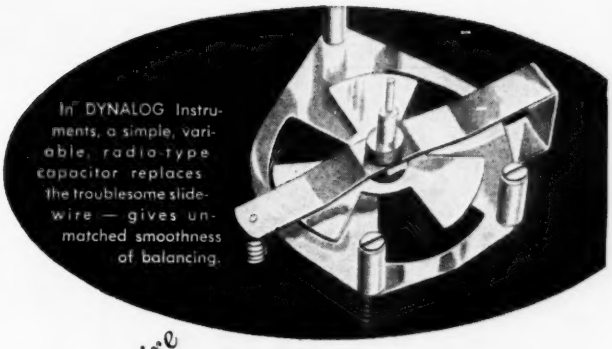
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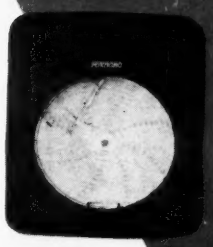

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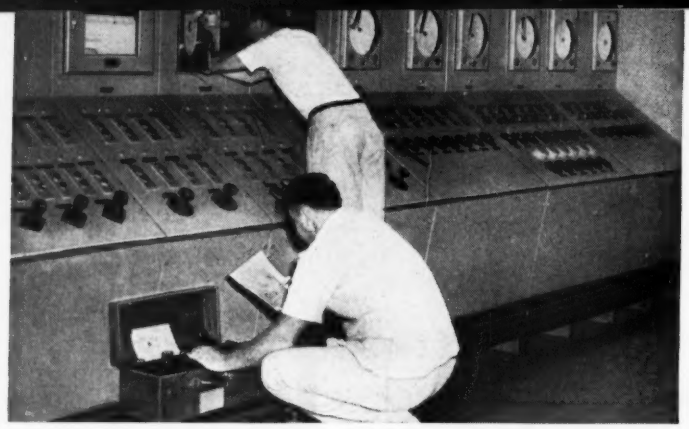

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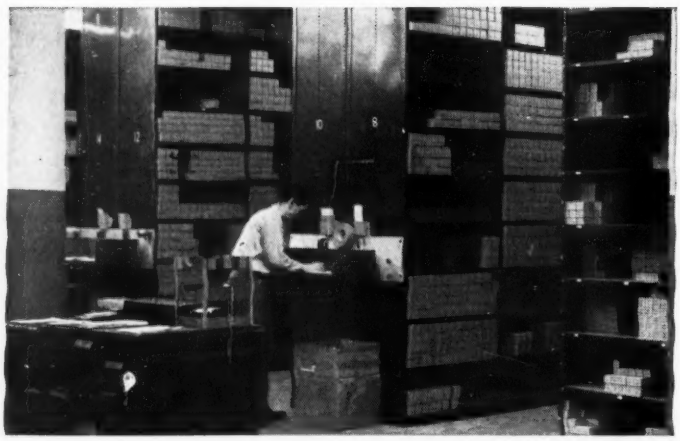

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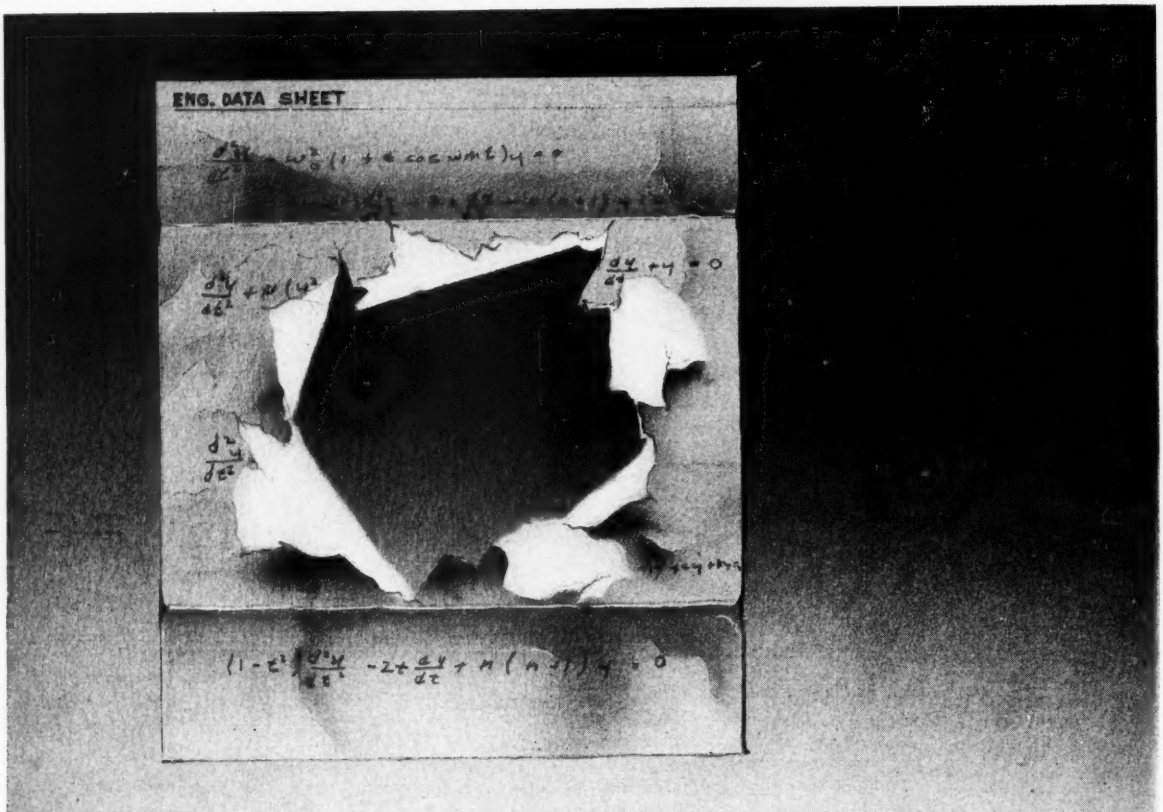

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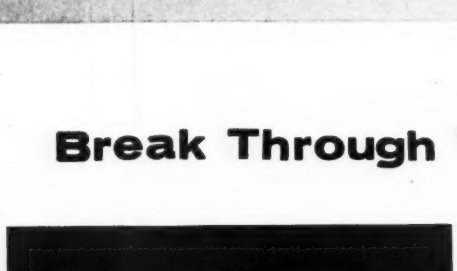

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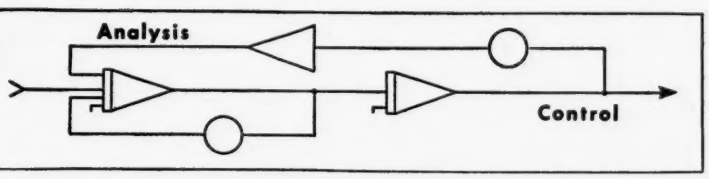

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PIECES

WESTERN S/C MEETING OF MAY 10 ON "CONTROL CONSOLE DESIGN"

Approximately 38 representatives of some 20 organizations gathered at Aerojet-General in Azusa, California on the afternoon of 10 May 1956 for the Western Simulation Council discussion of "Control Console Design and Centralized Control for Analog Computers."

After a late start (the right entrance to sprawling Aerojet is not easy to find) a business meeting concerning our planned Second Annual National Simulation Conference took so long that the subsequent discussion of "Control Console Design etc." had to be curtailed for refreshments and a look at Norm Irvine's analog computer lab.

Joe Hussey (Berkeley Scientific Division of Beckman Instruments, Richmond, Calif.), who was scheduled to give us the word on the current* thinking for their EASE (of) setup must have been one of those who got lost, because he came puffing in with *T. L. Nelson* (V. T. Rupp Co., Los Angeles, Calif.) just in time to start talking.

Hussey on EASE Philosophy

Joe began by saying that he wanted to make it plain that he was speaking as an engineer and not as a salesman (oh?). They have not sold one of the new computers which he was about to describe, and they won't until the development is complete. Joe said he thought one of the unusual features of this development was the use of private instead of Government dollars—certainly this is something of a novelty these days.

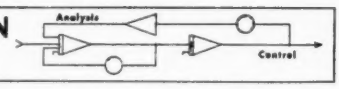
Development of the new EASE computer was premised on the idea that people are not so concerned with the initial cost of a computer as they are with the over-all costs of getting reliable information out of it. Joe believes that, typically, people are able to sell their management on buying a computer if they can show that they will keep it busy one-third of the time; six months later it will be working three shifts and still not be able to take care of all the work. Maybe the boy who recommended the computer in the first place gets a raise. Maybe the company gets more computers. Maybe they get acres of computers! But where do they find the bright boys to run them? Berkeley's philosophy is predicated on the fact that the answer is not more computers but computers which fewer people can set up and check out, in a shorter length of time.

Joe told us that studies have indicated that 70% of total computer time is spent on setup and checkout. Therefore, the Berkeley effort is directed toward reducing this percentage. Actual productive time is probably set by the fact that many simulation problems must be solved in real time. Joe believes the techniques which he went on to describe will cut setup and checkout time at least in half.

The first attack was to reduce the over-all number of patchcords required to set up any given problem. Every patchcord which can be eliminated, Joe said, eliminates one possible source of error. (Of course some wiseacre had to point out that it was two sources of error because a patchcord has two ends, either of which might get in the wrong hole.)

Berkeley has eliminated many patchcords by setting up scale-factor potentiometers and amplifiers in a standard configuration, with switches

*It is interesting to note the complete change in philosophy embodied in the EASE of yesterday and tomorrow. The original EASE was completely hand-patched, fully flexible, unstabilized, and inexpensive. The general realization that computers can save manpower, and that the more quickly they can be set up the more manpower they can save (and therefore the more economical they are in the long run), has led Berkeley and other vendors in the opposite direction— semi-automatic setup and check with attendant reduced flexibility, automatic stabilizing and high accuracy—and increased cost. For an argument against this trend see Dr. Schart's comments following this write-up.—Ed.



for an amplifier gain of 1 or 10. This module combination of potentiometers and input gain results in an over-all gain of from 1/100 to 10 without any patching at all. If, however, a high-gain amplifier is required, one patchcord can be used to jump the feedback resistor.

Bill Schart (Convair-San Diego, Calif.) asked whether this configuration was based on some preconceived idea of the kind of problems to be solved. To some extent yes, Joe replied; it was based on an analysis of the major part of the market.

Stan Rogers (Convair-San Diego, Calif.) suggested that the 1 or 10 gain switch might be set wrong just as things might be patched incorrectly, but Joe pointed out that with the switch you have an easily-read figure in front of you as opposed to checking on the correct plugging of a patchcord. Besides, said Joe, with their arrangement the gain is measured by putting a reference voltage on the input potentiometer and measuring the output of the amplifier. Thus an incorrect setting would show up, while any variation in the gain of the amplifier would be compensated.

Dr. Schart asked if the patchboards were removable. Joe said yes, that they had tried to provide everything for the convenience of the operator. If you are willing to pay enough, a little hand will come out and blow your nose for you! However, all of these conveniences cost money. The over-all initial cost of the computer he was describing, Joe estimated, might be as much as three times that of a similar computer having the bare essentials. But this would be offset by savings in manhours when the computer was placed in operation.

Someone remarked that this accuracy obtained by checking from the input of the pot to the output of the amplifier was fine, but how about errors resulting from thermal instability of the input and feedback resistors? Joe answered that here was a fine point that a lot of people had missed, that this was a powerful and valid reason for computer operators to demand that their computer room be airconditioned.

This got lots of laughs, and some remarks concerning the fact that computers can be charged off to contracts for which they are purchased, but airconditioning is a capital facility which must be paid for by the company! Joe countered this by saying that this was the wrong attitude —that if airconditioning is necessary for the proper operation of the computer they should buy it with the computer and have the computer manufacturer install it as a package.(!)

Then, getting serious again, it was pointed out that the thermal stability of a resistor is as much a matter of the previous history and the processing of the wire as it is the trimming of the resistor when it is manufactured. Reasonably stable resistors accurate to 1/10 of 1% are now available, however, so the capacitors are becoming the real limitation on the accuracy of the computer. A partial solution to the long-term drift problem is to keep interchangeable resistors and capacitors matched.

Joe says they are still looking for a really good resistor and would appreciate any information on the subject.

Dr. Schart asked if the gain of an amplifier could be checked with the amplifier connected as a summer or inverter and then the amplifier changed to an integrator. Joe replied yes, this could be done automatically by relays.

The EASE console setup is such that the operator sits with the patchboard practically in his lap. The controls are adjacent to his right hand, or if you are left-handed, they will turn their prints over and build it that way for you. The recorder is in a drawer of the console which can be rolled out for inspection. The operator should never have to leave his chair. The standard console can handle up to 106 amplifiers. Besides the connections already mentioned, these amplifiers have their summing junctions and grid leads (not necessarily the same) brought out.

The EASE module arrangement allows the customer to determine what ratio he would like to have of servos to operational amplifiers. A favorite arrangement has 16 servos, some driving tapped pots. The AMP patchboard can handle over 30 electronic multipliers and has 250 spare connections. The function generators take only one input and one output hole each. Amplifiers are remote from the console, and the distance from the potentiometers to the input resistors is about three feet.

It was interesting to note that Joe believes the day is coming in the near future when no electromechanical servos will be used in simulation (except perhaps in plotting boards). Electronic resolvers and electronic multipliers will be faster and more accurate. The only problem now is one of price, and even today they are reasonably competitive when the number of amplifiers required with servos is considered.

All indicators are also brought out to the EASE console. There are two banks of lights, one which registers instantaneous overload and one which goes on with overload and stays on until it is manually reset.

Joe says that they included automatic problem check in their computer because almost all of the necessary components were available anyway. They use Berkeley timers to time their relay operation accurately and to finish all timing pulses. They make their static check by introducing voltages to see if they add up right and letting the integrators go for a fixed time.

Then Joe was asked a question that has probably bothered all of us at one time or another. When one amplifier is used to sum and integrate, how can you check to determine that the inputs which collectively amount to the derivative are correct before integration? Joe answered that you do this when the amplifier is set up as a summer before being automatically converted to an integrator.

All of this automatic converting, switching, and so forth bothered *Willard Uplinger* (U.S. Naval Air Missile Test Center, Pt. Mugu, Calif.), who has had considerable trouble with relays, particularly with regard to a well-known digital voltmeter. "Is there," he asked, "Any such thing as a foolproof relay? How about the multitudinous ones which must be required in the computer you are describing? We have a situation where we might get most any answer. Sometimes it seems to depend on the time of day." Joe replied that there are all kinds of relays—that one reason their computer costs so much is the price of the high-quality relays used. These are all hermetically sealed.

Asked what information could be read out, Joe replied all amplifier outputs, all of the coded terminals, all initial conditions, and the gains at all amplifier inputs. You can hit a master scan button, go out for a cup of coffee, come back, and they will be printed out for you. Or you could hit the punch button and have a punch tape prepared. Pots can be set by a Clary keyboard and servo system, or they can be manually changed for empirical work. There are also half

a dozen Helipots available on the patchboard.

Someone wanted to know if there was a tilt button, just in case!

Nailed on the question of cost, Joe squirmed and would admit nothing except that he thought it would be between $100,000 and $800,000 depending on what you want. Someone wanted to know if you could get a keyboard setup for $180,000. Joe said maybe. He thought that the simplest operative form, stripped of everything but the bare essentials, would probably be $100,000. To that one could add as many accessories as desired. "They would cost money," said Joe, "But they can be bought. You can't buy engineers."

Norm Irvine, our host for Aerojet, had a lot to say on the subject of patchboards and computer setup, but time was running so short that he decided we should adjourn for refreshments in the Aerojet cafeteria and then come over to his lab where he would show us what he had done instead of talking about it.

As usual, the bull sessions during the break were interesting, as was Norm's lab. The Aerojet analog computation laboratory is unique in that the bulk of the equipment was designed and built by Norm and other Aerojet personnel and therefore embodies many interesting and unusual features. However, because your Editor is not sure which ones are considered proprietary (and also because he didn't understand some of them) we had better not try to go into detail as to what we saw.

* * *

Having noted the pointed remark Dr. Schart had made, your Ed. subsequently asked him what he was driving at, and received the following answer.

"The speaker implied that the shortage of programmers and operators for analog computer equipment is best overcome by the reduction of the sophistication of the patching schemes. Another method of overcoming this shortage is to provide training to create new programmers and operators.

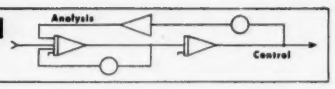
"In addition, in my opinion, the full power of the more sophisticated machines* has not been fully exploited. There are many problems which can be solved on these machines which are not being solved because the user is not fully aware of their capabilities. Again, the solution consists of educating the user and broadening his perspective as to the use of these machines.

"Undoubtedly, Berkeley Scientific Division has decided there is a market for the machines they are proposing. However, I hope that other organizations will use the alternate approach which I propose, so that the computer art will advance on that front as well.

"It is interesting to note that a similar conflict between sophistication on the one hand and simplicity for the programmers on the other exists in the general-purpose digital-computer field also."

*i.e., the fully flexible ones where the operator has complete freedom in the use of all components.

SIMULATION COUNCIL



MIDWESTERN S/C MEETING OF MAY 14 ON "OPERATIONS RESEARCH"

Minutes of the 14 May meeting of the Midwestern Simulation Council, prepared and sent to me by *Hal Coleman* (Bendix Aviation Corp. Research Laboratories, Detroit, Mich.), tell us that *Rodger Merrill* welcomed them on behalf of Battelle Memorial Institute, Columbus, Ohio. After a brief discussion of current technological demands, Mr. Merrill said that to be sure the visitors would be able to carry something worthwhile away with them Battelle had arranged to provide coffee and doughnuts!

Because ye Ed. was too far away from those doughnuts and coffee to hope to ad lib in context, the rest of this writeup will consist of excerpts lifted 'almost' verbatim from Hal's notes. However, because of that almost, quotes will be omitted.

Debeau on Basic Functions

The first speaker was *Dave Debeau* (Management Research Division, Battelle Memorial Institute). Being an expert on Operations Research, he chose not to define the subject but only to explain and describe its functions, which are observation, theory development, and experimentation. The two largest categories in Operations Research are military and industrial. In general, the military by nature is easier to evaluate because results of changes in techniques can be observed directly. The difficulty in industry is to obtain boundary conditions; it is virtually impossible to control the conditions of the experiment. One cannot control or ask that changes be made in an environment merely to get more data.* Because of these limitations, the Operations Research Analyst must depend more and more on simulation.

In the field of simulation there are several methods. Some use charts which are always static and exact. Others are flow diagrams which are always static and are usually exact. Another type of simulation is a physical model which may be either static or dynamic. (An example of this is a highway network.) An analytical model can be either static or dynamic, exact or stochastic. As the systems of equations in analytical models become more complex, the use of computers becomes necessary. Both analog and digital computers have been used satisfactorily for machine solutions.

Another form of simulation is *Operational Gaming*. This approach uses people, and nearly always deals in dynamic and stochastic processes. Often it is a combination of several of the foregoing techniques such as flow diagrams, physical simulations, and analytical simulations. An example would be the study of the flow of traffic into an airport where all the pertinent information would be recorded. Then an introduction of jets into the traffic pattern would be made, one at a time. Human beings would have to make decisions, and the study of these decisions would be the crux of the Operations Research experiment.

In the question period that followed, *Milt Warshawsky* (Wright Air Development Center, Wright-Patterson Air Force Base, Ohio) asked if the equations tended to be more suitable for digital techniques rather than analog. The answer was yes, because of the predominance of algebraic rather than differential equations.

Jerry Kennedy (Electronic Associates) asked Debeau if their work had contributed to any management decisions by Battelle with regard to internal operations. Dave answered

*Process industry people will appreciate this!

that it had in the instance of report writing.

Hal Coleman asked whether a number could be assigned to the percentage of successful predictions and was told that this was difficult. However, one result came within 10 to 15% of the predicted values.

James Edwards (Mid-Century Instrumatic Corp.) asked whether it was possible to assign statistical probability figures to the work. Dave answered that they tried to, but could not always do so because of their inability to experiment.

Bill Field (Carbide and Carbon Chemicals Company) asked what order of data accuracy was required. Dave replied that this varied with the problem from 0.1% to 15%.

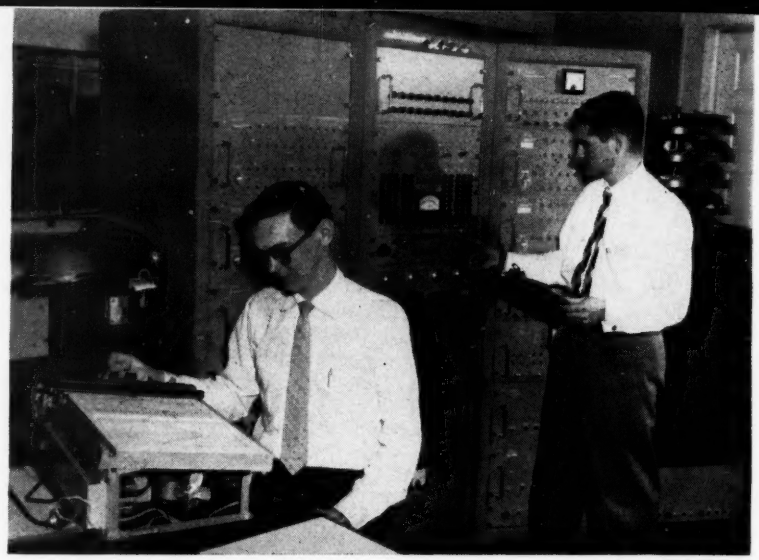
Dick Weber (Cincinnati Milling Machine Co., Cincinnati, Ohio) said that it seemed to him that these problems could be done faster and more conveniently on an analog computer, particularly as one may be interested in examining several sets of coefficients. The reply was that linear programming is reasonable only if all of the coefficients are known. As a result the analog has very positive advantage over digital when any changes are to be made.

Pyne on Linear Programming

The next speaker was *Insley B. Pyne* (Princeton University), who is considered one of the few experts in the country in the field of linear programming with analog computers. He described a technique derived from his experience with the equations and restrictions. He also indicated the type of gating and circuit analysis necessary for the performance of this operation. A method of checking is to start at various points in the system and see whether in each instance the loop stabilizes on the same point. At the present stage of the art he is not at all sure that most computer installations should build themselves giant matrix boards. At Princeton a modest linear programming board is under development, more or less as an experiment. He feels, however, that the newer programming methods such as, for example, the card programming system recently developed by RCA for one of their newest analog computers, have the advantage of being more general and may remove the necessity for such a matrix board.

Jackson on Problem Types

Warren Jackson (Standard Oil of Ohio) indicated in his talk that the analog approach was limited to particular types of problems; the big limitation is the amount of computer equipment available. Although individual problems may contain a large number of zero coefficients and thus be adaptable to a standard computer, changing to another situation would entail a large amount of rewiring.



Dave Prince (at the controls) and Bob Johnson (at plotting board) of new analog computer facility at Georgia Tech.

Most of their investigations were studies requiring several hundred solutions. They could have 7 equations in 16 variables, which would require a setup time for their analog computer of eight hours. The running time, however, would be only about one-half minute per solution. The payoff came in changing to subsequent problems. Then you can look at each run and decide which is to be discarded. Warren's equipment required 32 diodes and 39 pots, while a general-purpose board would require 225 pots for a 15 x 15 matrix. Other techniques were presented which do not use switches, but which need more programming and use silicon diodes with a 0.2 to 0.3 volt residue.

Reference was made to studies conducted to determine digital techniques for linear programming, and a comparison was made between the 650 and the Simplex.

A discussion followed as to whether it would be possible to do a lot of the analysis automatically. It was decided that in time this would be possible. *Jerry Kennedy* indicated that it would be possible to vary the solution by the technique of wiggling pots. He also felt that there was no need for using expensive pots on a matrix board.

Brit Lux (Bendix Research Laboratories, Detroit, Mich.) asked how accurately the pots are set. They are set as well as possible. Good accuracy in problem solutions has been obtained.

Bob Howe (University of Michigan, Ann Arbor, Mich.) asked whether the capacitors were important. Insley stated that they should be uniform. Bob then asked if different capacitors can be used in the feedback in slow problems. Pyne replied yes they could be used for problem speed up.

Warren Jackson remarked that they had three different-sized capacitors on their computer, which Insley agreed was a good idea.

Herbert Schultz (Goodyear Aircraft) asked about nonlinear problems. Insley explained that it was their philosophy to stay away from them!

With the conclusion of the questions a tour was made to the analog facilities at Battelle to show off some new equipment received since the last visit of the Simulation Council.

Information (Without Theory)

The National Simulation Council is going to cooperate with the Denver Research Institute of the University of Denver when that organization holds its Third Annual Symposium on Digital and Analog Computers in Denver on 30-31 August 1956.

The extent of the participation will be threefold:

1. On the afternoon of Thursday, 30 August, there will be a panel discussion of Combined Analog and Digital Simulation organized and participated in by NSC representatives.
2. All who are interested will be invited to remain after the panel discussion to consider two questions: the formation of a local SC, and plans for our annual NSC conference. It is hoped that the latter can be

settled at that time.

3. All at the DRI conference will be invited to participate in some sort of informal get-together sponsored by the NSC Thursday evening. The objective will be to get acquainted with others having similar interests. It is hoped this will be as successful as the similar soirée held in Dallas last Feb.

Only other info of interest this month is that Georgia Tech has gotten their new analog computer facility under way, as you can see in the accompanying photograph.

Thot (not original)

Science is only controlled curiosity.

Computer Events

Other events on page 1350

Association For Computing Machinery

Date: 27-29 August 1956
Place: University of California at Los Angeles, Los Angeles 24, Calif.
Subject: 11th Annual Meeting
Info: ACM, Box 3251, Olympic Station, Beverly Hills, California

Denver Research Institute, University of Denver

Third Annual Symposium on Digital and Analog Computers
Date: 30-31 August 1956
Place: Hotel Albany, Denver, Colo.
Info: William B. Kennedy, D.R.I., University of Denver, Denver 10, Colo.

DDA Council (Note changes)

Date: 20 August 1956 (the Monday preceding WESCON)
Time: 1030
Place: Autonetics Division, North American Aviation, 12214 Lakewood Blvd. (at Imperial), Downey, California
Subject: Future plans and common problems of Digital Differential Analyzer users.
Info: Mr. Robert Geiger, Autonetics Div.

Midwestern Simulation Council

Date: To coincide with National Electronics Conference (Oct. 1-3)
Place: Chicago, Illinois
Subject: "Simulation of Hydraulic Systems"
Information: Tammen & Dennison, Engineering Consultants, Chicago, Illinois

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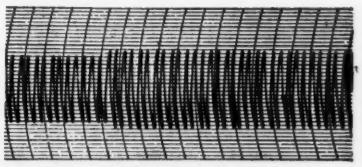
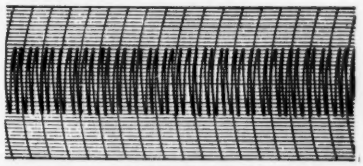


Output of typical electromechanical regulator in response to step change in input voltage. Average correction rate of 6v. per sec.



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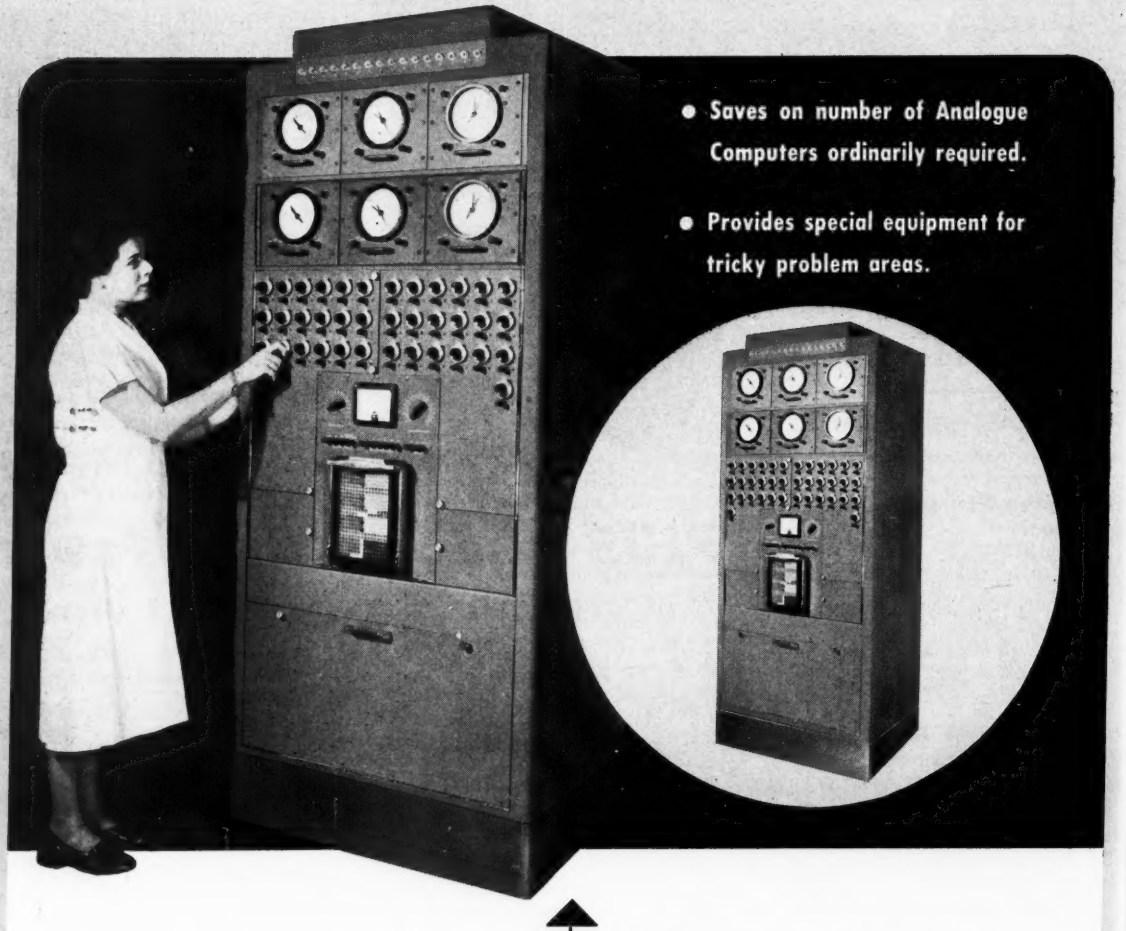

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(1) Electronic Computers-analog, digital; general purpose, special purpose.

(2) Office Automation—Data Handling.

(3) Process Automation.

(4) Automatic Production, Assembly, Fabricating.

(5) Electronic, Hydraulic, Optical and Pneumatic Automation Techniques and Components.

(6) Servomechanisms.

Each clinic class will comprise a 90-minute *lecture and demonstration* based on *operating equipments* exhibited at the Exposition.

Each registrant can sign up for six clinic sessions in one (or more) of the six basic fields.

Principals to date in the clinics include:

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Early registrants can select their six sessions in one or more of the above basic fields. Class schedules will be sent to each registrant.

The above clinic sessions are typical of 100 sessions, each of which will comprise lecture-demonstration classes in front of **operating equipments.** Depending on the size of room within which the equipment is located, classes will be restricted to from 10 to 35 registrants. Therefore, industrial managers and engineers are urged to make early reservation of seats for sessions on equipments in which they are particularly interested.

Journal of the S C M A . . .

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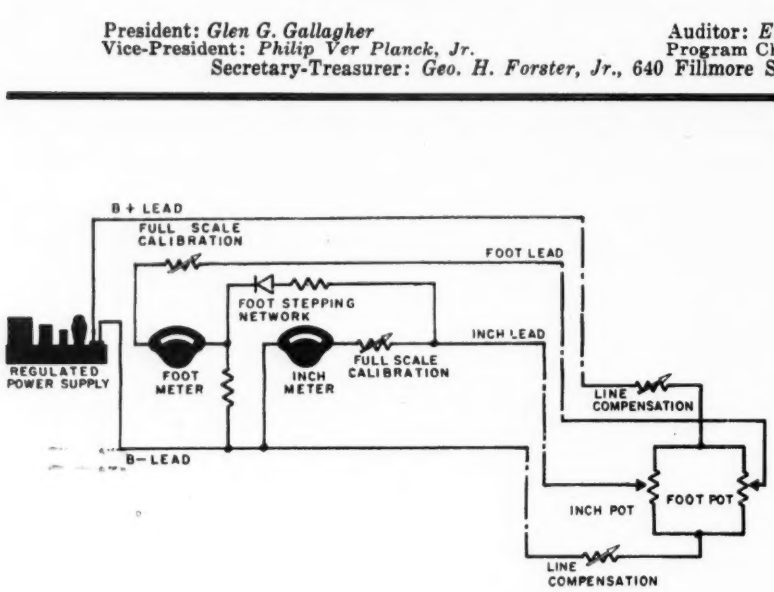

Fig. 1. Typical analog-type tank gaging system.

Selection and Installation of

The two basic types of tank gaging systems are (1) analog type and (2) pulse type. Although the former are usually used for remote gaging up to a few thousand feet and the latter for "telemetering" over hundreds of miles, selection must be made only after consideration of (1) type of communication facilities between tank and indicator and (2) system flexibility required. Field wiring installation and maintenance factors are discussed in detail.

H. DICKINSON
The Vapor Recovery Systems Co.

FLOAT-OPERATED TANK GAGES are still the most common instruments used in the petroleum industry for level measurement. This article discusses the factors behind the selection of system type, as well as the factors that enter into installation and maintenance of the installed remote-transmitting, float-operated liquid-level gaging system.

Figs. 1 and 2 show typical float-operated liquid-level gages which consist of (1) a float which senses the liquid level; (2) a steel tape attached to the float, which runs straight up to the tank top over idler sheaves and then down to near ground level on the outside of the tank; (3) a counterweight or other form of pull-back or tension mechanism; and (4) means for reading the level indication. In older type gages the indication was in the form of graduations on the tape itself, as on a measuring tape. Newer types of gages provide improved readability by direct-reading dials and counters which are driven by the perforated tape, similar to a chain driving a sprocket.

Thus, the inital output of the tank gage consists of *mechanical displacement,* usually in the form of shaft rotation (for convenience, each foot of liquid level movement usually produces one revolution of the output shaft). Most accepted methods of liquid-level data transmission utilize this mechanical output to drive or position a transmitter element. When considering the remote transmission system we shall emphasize the factors influencing the "accuracy" of the transmission system itself—that is,

August Meeting: *Thursday, the 16th, Rio Hondo Country Club, Downey, Calif.*
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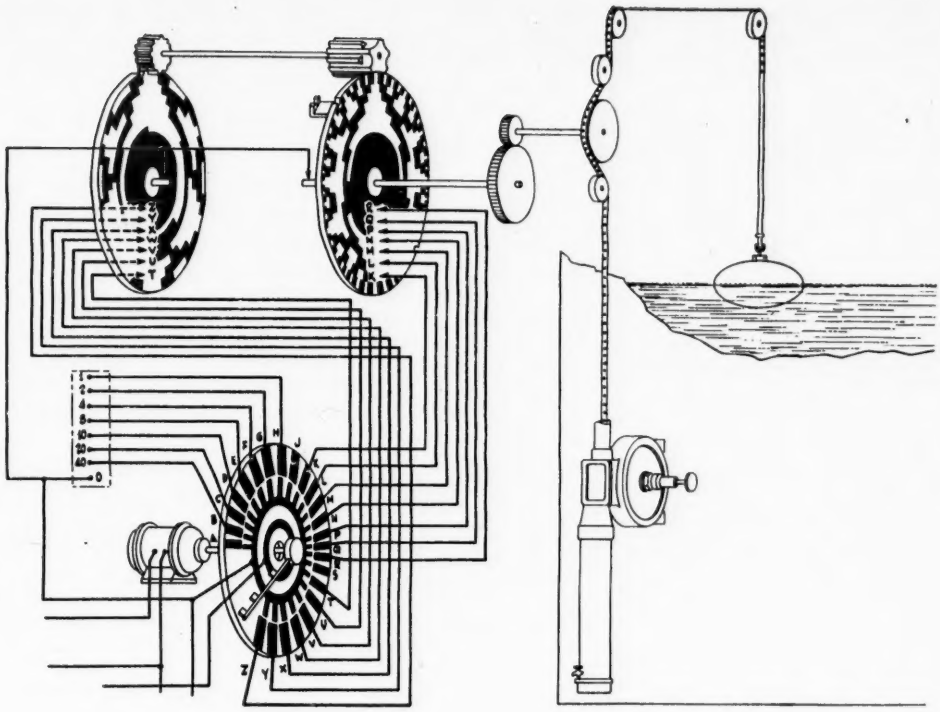


Fig. 2. Typical pulse-type tank gaging system uses coded pulses to indicate tank level. Two coded discs (at top) develop 14-bit code that can indicate any height up to 60 feet to nearest 1/8 inch; one disc indicates feet, the other inches. Motor attached to lower coded disc drives wiper that rotates once around the disc whenever "interrogated" by operator at remote indicator (not shown).

Remote Tank Gages

the system's ability to reproduce the measurement provided by the tank gage.

Types of Transmission Systems

Indication of liquid-level information at some point other than the place of measurement involves equipment that falls into one of two general categories. The first system is used where the transmission distance is not great—usually only a few thousand feet—and it has become commonly known as a *remote-gaging system*. The second type is one that may involve hundreds of miles of transmission and can be called a *telemetering system*. However, distance is not the only consideration in selecting the basic system. There are four basic factors to consider—(1) distance, (2) type of communication facilities between tank and indicator, (3) type of signal, and (4) flexibility required.

The second consideration concerns the *type of communications facilities or wiring between the tank farm and the remote liquid-level indicator*. In the first type of system (remote reading), we require a considerable number of conductors, ranging from an average of less than one conductor per tank to a possible four conductors per tank. Thus the total number of conductors required by the main cable for a 60-tank installation can be from 18 to 240, depending on the type of system and equipment used.

The second type of system—the telemetering type—usually provides a means for connecting a single communications channel, such as a two-pair line, to each tank as it is gaged. This arrangement is similar to an automatic telephone switchboard. Thus, when the number of conductors that can be installed between the tank farm and the receiver is limited, the telemetering-type system *must* be used. Note that this consideration ties in directly with the distance concept because the problem concerning the number of conductors increases in direct relation to the distance.

The third consideration is the *nature of the electrical signal* used for transmitting the intelligence. Generally speaking, remote-reading systems use an analog-type signal, either a voltage, current, or phase proportionate to the liquid level. (Where the analog signal is needed for continuous reading or for control, a remote-readng system is indicated.) The telemetering systems, however, usually utilize pulse techniques for the transmission means because these are better adapted to the problems of long-distance transmission.

The fourth consideration concerns the *type of operation and flexibility required*. Remote-reading analog systems are flexible; they can be arranged so that readings can be taken simultaneously at several points; they can provide either continuous indication for each tank or a single indicator with tank selection switches; and they are usually either instantaneous reading or relatively fast.

The pulse systems are not as flexible. The signal used is sent on a sequential basis like a telegraph signal and, therefore, a definite time is required—from a few seconds to about 25 seconds for the equipment available today. Although more than one receiver can be provided for a pulse system, a reading obviously cannot be taken for any tank in the system at any given time. In this respect the systems are similar to a telephone party line; only one message at a time can be transmitted.

Thus, the four basic considerations in determining the type of system best suited for a given application are: (1) distance, (2) type of communications facilities, (3) type of signal, and (4) type of system operation or flexibility required.

It would appear that the first three considerations are all directly related to distance and, therefore, the second and third conditions have little bearing on the selection. However, consider the case where it was desired to remotely gage tanks that were located only a few hundred feet from the receiver location, but a highway existed between the receiver and the tanks. It was not possible to install a cable across the highway, but it was possible to use a leased telephone line. As the telephone line consisted of only a single pair of wires, the pulse telemetering system was used, despite the short distance.

There also have been cases where considerable distance was involved but continuous reading indicators were required for each tank; the remote-reading analog system was best suited because multiple transmission channels would have been required for either system. In installations where control is required using the liquid-level signal as the control input, the analog system is required.

Varec Analog System

Figs. 1 and 2 show the "Varec" analog and pulse systems, respectively. In the analog system the transmitter contains two precision potentiometers which are used as voltage dividers. One is the "inch" potentiometer, the other is the "foot" potentiometer. The former makes one complete revolution per foot of level change; the latter makes 10 turns for 60 feet of level change. D-c voltage from a power supply in the receiver is connected across the potentiometers and, therefore, the voltage at the sliders depends on tank level.

The indicators at the receiver unit are two voltmeters; one has a scale graduated in feet, the other in inches and eighth inches. A portion of the "inch" voltage from the inch transmitter potentiometer is connected to the foot indicator in reverse polarity so that the foot indicator does not move until the inch indicator indicates a full 12 inches, at which instant the inch voltage returns to zero and the foot pointer moves upscale one foot. As the foot indicator moves in 1-foot steps, errors in taking foot readings are eliminated.

Varec Pulse Code System

In the pulse system (Fig. 2), the float motion causes proportional rotation of two coded discs—an inch disc and a foot disc. The inch disc makes one revolution in 24 inches; as readout is desired to $\frac{1}{8}$ inch, the code is selected to have 8 x 24, or 192 parts.

The foot disc has a 60-part code to cover a total tank height of 60 feet.

When a reading is desired, the operator at the remote receiver dials a code which connects his receiver to the desired tank. When the connection is made, the motor shown makes one revolution, and the brushes on the lower disc pick up a 24-pulse code depending on the position of the two coded discs and, therefore, definitive of tank level. The pulses are decoded at the receiver to light lights that show tank number and height in feet and inches to the nearest $\frac{1}{8}$ inch.

Once a system has been decided on, the next problem concerns the installation. We can assume there will be no difficulty with the mechanical work and will discuss the electrical installation.

Type of Wiring Installation

In practice, both the overhead cable and the underground type cable are used. The most common type of installation uses overhead cable from the receiver to the tank firewall, and an underground cable from the fire wall to the tank transmitter unit. The type of cable used may be either lead covered, plastic sheathed, or plastic sheathed with a metallic shield; the choice depends on consideration of mechanical damage which may result from plant operations, lightning, etc.

Importance of Good Field Wiring

In considering field wiring, the first problem concerns the material used. A wide choice of excellent cables are available. Practically any plastic insulated wire or cable is suitable for wiring a remote gaging installation, particularly the type using a polyethylene insulation. The wire or cable used should, of course, have a conductor size large enough for the distance involved, have an insulation suitable for the voltages to be used, and should be a type suited to the environmental conditions and type of installation. For the remote-reading analog-type system, one of the most important considerations is the insulation quality. A good quality plastic-insulated cable should be used, although, as will be noted later, the cable itself may not be the influencing factor in this respect.

The second consideration for the field wiring is *workmanship.* The installation of the transmission system requires more attention to details than an installation for a power system. The basic consideration is the *insulation resistance or leakage of the cable.* It is important that leakage paths be either eliminated or minimized throughout the system. Where terminal strips are used, the conductor should not have the insulation stripped back any farther than required, and the wire after leaving the terminal should not come in contact with other wires or the metallic housing or ground for as great a distance as possible in order to establish a reasonably long leakage path from the terminal to other conductors or ground. All the splices and connections in the systems should be made to have as low a resistance as possible.

The third consideration encompasses the first two and concerns the insulation of the system as a whole. One basic consideration in this respect, which is commonly overlooked, is the *terminal strips* used throughout the wiring system. As was mentioned, the wire or cable used will probably have good insulation and will, normally, cause little trouble as far as leakage is concerned. Although we would not tolerate breaks in the cable insulation, and would reject any cable where the bare conductor was showing, we purposely break the insulation and expose conductor whenever we install a terminal strip. Any terminal is a current-carrying exposed metal part, and should be viewed with suspicion.

Terminal strips are needed in field wiring both for making changes to the system and trouble-shooting. Except for these considerations, there is no justification for use of terminal strips. A well-made and insulated splice is far more permanent, is just as convenient to make, and will eliminate almost entirely the leakage problems from this source.

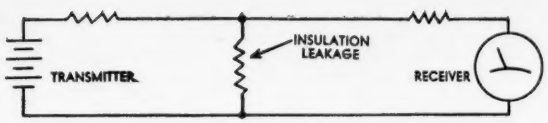


Fig. 3. Leakage in this type of analog-type system causes reading to be low.

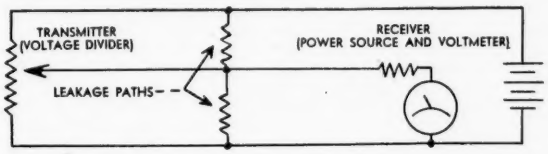


Fig. 4. Where power source is in receiver of analog-type system, the effect of leakage paths varies with tank height.

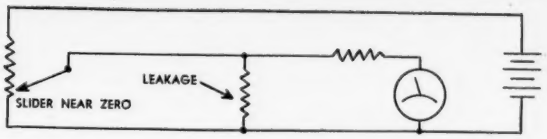


Fig. 5. Leakage path to negative end of power source is almost shorted out and thus has little effect when slider is near zero in this analog-type system.

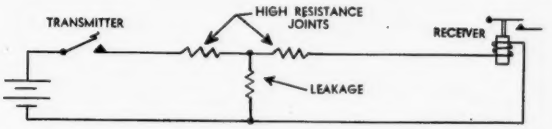


Fig. 6. In pulse-code systems, either high-resistance joints or leakage paths or both can cause pulse signal to be too small to operate receiver relay.

Where terminal strips are used, it is important that the junction box enclosing the terminal be as moisture- and dust-tight as possible. Where dust and moisture can come in contact with a terminal strip, sooner or later a leakage path will develop as the dust will settle on the strip and then absorb moisture and provide a conducting path between conductors or between conductors and ground. It often is advisable, after the installation is complete, to completely insulate all the current-carrying exposed metal parts on the terminal strip with an insulating varnish. Where it is not desirable to use anything as permanent as a varnish, it is possible to use some compounds, such as DC-4 Silicone, to coat the exposed metal parts to prevent leakage.

Assuming the terminal strips are protected from dust and moisture, no protection should be required, provided that a periodic maintenance or inspection check is made of the system junction boxes.

Effect of Leakage on an Analog System

In discussing field wiring, considerable stress was laid on the insulation quality of the system. This factor takes on its greatest importance when the system being installed is of the remote-reading analog type. As the analog-type signal can be represented by a voltage amplitude, we will consider the effects of leakage currents on such a signal.

In this type of system, the transmitter output is a voltage that is proportional to the liquid level. Therefore, we can represent the transmitter as a voltage source of high resistance, and the receiver as a voltmeter of high resistance (Fig. 3).

These two devices are connected by field wiring. The amplitude of the voltage on the field wires represents the liquid level. If a leakage path exists between the two conductors, a load is presented to the transmitter voltage source, resulting in a voltage drop due to the transmitter's output resistance and, therefore, the voltage indicated by the receiver voltmeter is lower than the correct value.

Leakage to ground or between the conductors, resulting in a lower-than-correct reading, is not the only possible leakage path. Actually, in the common type of system, the voltage source is located within the receiver unit and is fed to the transmitter, which can be represented by a voltage divider as shown in Fig. 4.

The output of the transmitter or voltage divider is then conducted back to a voltmeter in the receiver unit. Therefore, we have two possible leakage paths—one from the transmitter output lead to the negative or ground lead (which will cause the reading to be less than the correct value) and one from the transmitted output lead to the positive power lead (resulting in a reading that is higher than the correct reading).

An oddity that causes confusion to the man attempting to service the equipment is that the symptoms seem to indicate that the leakage comes and goes. Although this is possible, the leakage is generally constant but its effect varies with the liquid level in the tank. Referring to Fig. 4, where the liquid level in a tank is close to zero, the transmitter voltage—divider slider will be near the negative end and will present an extremely low resistance output; hence, the leakage path between the transmitter output lead and the negative lead will have little or no effect on the output voltage (Fig. 5). Likewise, the leakage paths from the transmitter output lead to the positive lead of the power source have little effect on the transmitter output voltage. This same condition, of course, is true in the opposite sense when the tank is at an extremely high level. Therefore, leakage paths will have their greatest effect somewhere in the mid-scale range and, with a fixed leakage, the effect of leakage varies with the tank level.

Leakage and Resistance Considerations in a Pulse System

The pulse-type system is not as sensitive to insulation leakage as the remote-reading analog-type system. However, a much longer transmission path usually is involved when a pulse system is used and, therefore, there are more possible leakage paths and high-resistance joints.

In a pulse-type system the transmitter can be represented by a voltage source and telegraph key, and the receiver represented by a relay or telegraph sounder (Fig. 6). Connecting these two units together, we have a pair of conductors that, due to the distance involved, may have considerable series or loop resistance. It is obvious that the relay in the receiver unit requires a definite voltage for proper operation. Hence sufficient leakage across the telemetering line can result in malfunction due to the reduced voltage pulse at the receiver. High-resistance joints have the same effect. Hence con-

sideration of high-resistance joints in a telemetering line is probably as important as leakage.

Location of Equipment

Usually, there is little choice in selecting the location of the equipment used in remote gaging systems. The transmitter units are located at the tanks, and the receiver unit location is determined from a standpoint of operator convenience. As far as possible, however, an attempt should be made to locate equipment where it will be free from dust, moisture, vibration, and extremes in temperature. It should also be located in such a way as to provide access for service. As the nemesis of all electrical equipment is moisture, this should be one of the prime considerations in selecting a location for the equipment.

Maintenance

Routine maintenance is the best means of preventing trouble in any type of equipment. The following are worth noting:

(1) Check receiver calibration periodically.
(2) Routine replacement of tubes in electronic systems.
(3) Check critical contacts in pulse-type systems.
(4) Routine spot check of transmitters for excessive contact wear and presence of moisture.

Trouble-Shooting

When troubles are encountered or reported, they will usually fall into one of the following categories:

(1) System completely out of operation on all tanks.
(2) System completely out of operation on one or more—but not all—tanks.
(3) Reading errors on all tanks. Errors may be consistent or intermittent.
(4) Reading errors on one or more—but not all—tanks. Likewise, these errors may be consistent or intermittent.

The following procedure will help in trouble-shooting the system, based on the above mentioned symptoms.

Condition No. 1: *System is completely out of operation.* The trouble will exist either in the power source to the units or in a unit common to the entire system, or failure of the comunications cable. Check in the following order:

A. Check for power at all units common to the complete system.
B. Check the fuses in such units.
C. Check the telemetering line for continuity and shorts.

Condition No. 2: *System completely out of operation on one or more, but not all, tanks.*—The trouble probably exists in something unique to the tanks affected. The following checks should be made:

A. The transmitter unit. Simplest and most effective method of checking is by substitution.
B. The transmission cable to the transmitters affected. In most systems the wiring to the tanks includes conductors that are common to several, and possibly all, tanks. In this event, the field wiring should be checked for a correlation between the routing of the conductors and the transmitters involved in the trouble. For example; if the last 3 transmitters on the line feeding 6 units do not operate, the conductor should be checked for a break between the 3rd and 4th transmitters.
C. If items A and B check out OK and the trouble is still present, it is logical to suspect that the *selection portion* of either the receiver or selector is the cause; either the correct selection may not be made or a poor contact may exist in the selection switch or relay.

Condition No. 3: *Reading errors on all tanks.*—This symptom is rare and the cause depends on the type of system, as follows:

For the electronic or remote-reading analog type, the following checks should be made:

A. Check the receiver for calibration. If it calibrates, the trouble is external to the receiver. If the receiver cannot be calibrated, the trouble exists in the receiver power supply; tube replacement is indicated.
B. Assuming the receiver will calibrate correctly, check any and all gaging conductors common to the entire system for insulation value.

For pulse-type systems, the following checks should be made:

C. To check a pulse-type receiver, it is necessary that either a test transmitter unit or an oscillograph be available. If a test transmitter is available, it should be connected directly to the receiver and the combination operated. A correct reading generally indicates that the trouble is external to the receiver; an incorrect reading indicates that the receiver requires service.

If an oscillograph is available, it can be connected to the telemetering line to determine whether the receiver is receiving the correct signal. Assuming the correct signal is received but an error still exists in the receiver reading, the receiver is obviously defective.

D. Check the output of the remote selector unit. Where the checks indicate the receiver unit is OK, the output signal from the remote selector should be checked by reading the signal on the telemetering line at the selector output terminals or by injecting a signal into the telemetering line with a test transmitter. Once it has been determined that the correct signal exists on the telemetering line at the remote selector, it should be possible to then determine whether trouble exists in the telemetering line to the receiver or within the receiver unit itself.
E. Assuming that all of the equipment and the telemetering lines check out OK to this point, the next step is to disconnect all conductors between the selector and transmitter that are common to all tanks and connect the test transmitter to the selector input and operate the system. This test will indicate whether the remote selector unit is capable of receiving and re-transmitting the correct signal.
F. Again, assuming all tests check out OK, the trouble obviously must exist in one of the common conductors between the selector and transmitter. These conductors should be completely disconnected from the remote selector and from the transmitters, and continuity and insulation checks made on the conductors in question.

Condition No. 4: *Reading errors on one or more, but not all, tanks.*—This symptom usually eliminates any unit common to the entire system. The following check procedure should be followed:

A. Substitute one of the defective transmitter units with either a known good transmitter or with a test transmitter unit and operate the system.
B. If the above check did not provide a correct reading, the field wiring between the receiver or selector and the transmitter units should be suspected; the field wiring should be disconnected and continuity and resistance checks made.

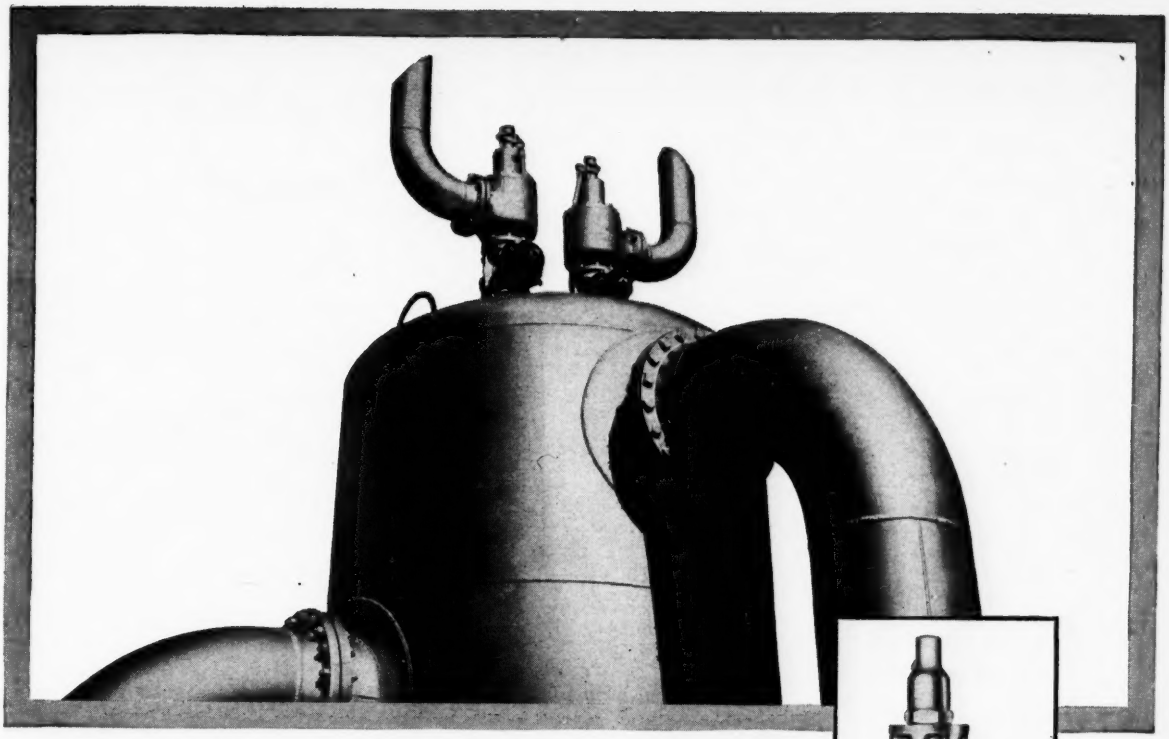
When trouble is encountered in either system, the first and most important thing is to eliminate those links in the system which are not defective.

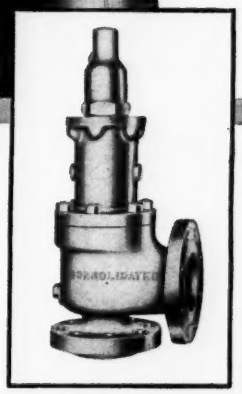
For the remote-reading analog-type system, the three basic units are: (1) the receiver unit, (2) the field wiring, and (3) the transmitter units.

Frequently one or more of these units can be eliminated by virtues of the symptoms reported. Whether this is possible or not, the most straightforward and reliable method of determining the defective unit is by means of substitution of known good components. For example: if a given transmitter is suspected of causing trouble, it can be subsituted by a known good unit and, therefore, prove or disprove the unit in question. Where the field wiring is suspected, it is possible to connect a transmitter unit directly to the receiver, thereby eliminating the field wiring from the test and proving whether or not it has any effect on the reading.

The pulse-type systems have five basic components: (1) the receiver unit, (2) the telemetering line to the remote selector, (3) the remote selector unit, (4) the field wiring to the tanks, and (5) the transmitter units.

Although slightly more complex, the pulse systems can be approached with the same common-sense line of reason, and the various links in the chain proven or disproven by means of substitution.





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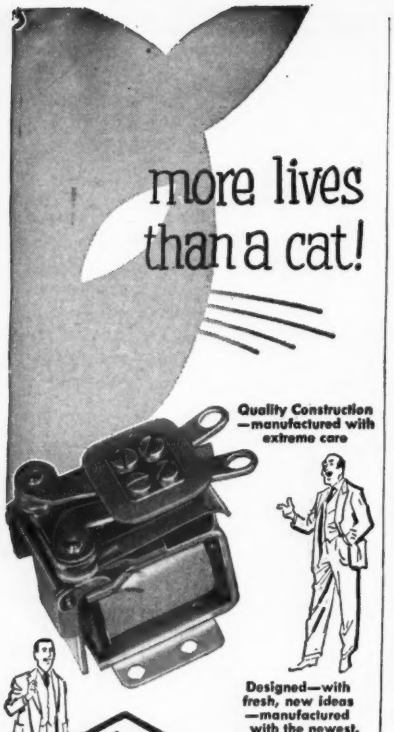

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AEMCO relays are available in a wide variety of spring and coil combinations, operating potentials and contact ratings. Types include: Open, can, plug-in base, hermetically sealed, midgets, dual-purpose, delayed make or break, circuit control, current and potential relays. Should one of the hundreds of AEMCO relay types fail to meet your exact requirements, we will be happy to design and build a unit to meet or exceed your specifications.

WRITE TODAY

For more information on the standard AEMCO relay line, write for your free descriptive bulletin today!

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AUTOMATIC ELECTRIC MFG. CO.

53 STATE ST. • MANKATO, MINNESOTA

For more information circle **161** on inquiry card.

INSTRUMENTS and AUTOMATION Events

For other computer Events see page 1341.

July 22-28

8th International Congress of Radiology, Mexico City, Mexico, For information write Jose Noriega, Tepic 126 (2e piso), Mexico, D.F. 7, Mexico.

July 23-27

Gordon Research Conference on Instrumentation, American Association for Advancement of Science, Calley Junior College, New London, N. H. For information write W. G. Parks, Dir., Gordon Research Conference, Dept. of Chemistry, University of Rhode Island, Kingston, R. I.

July 23-August 11

Wayne University Computation Laboratory, Summer Program, Wayne University, Detroit, Mich. For information write A. W. Jacobson, Dir., Computation Lab., Detroit 1, Mich.

August 8-10

Instrumentation Short Course at Instituto Tecnologico y de Estudios Superiores de Monterrey. For information write Carlos Duhne, Head, Chemical Engrg. Dept., Instituto Tecnologico y de Estudios Superiores de Monterrey, Monterrey, N.L., Mexico.

August 9-10

Fifth Annual X-ray Analysis Symposium, sponsored by Denver Research Institute of Univ. of Denver, Denver, Colo. For information write James P. Blackledge, Denver Research Inst., Univ. of Denver, Denver 10, Colo.

August 15-17

National Turbine Powered Air Transportation Meeting, sponsored by Institute of Aeronautical Sciences. For information write Inst. of Aeronautical Sciences, 2 E. 64th St., New York 21, N. Y.

August 19-24

6th International Symposium on Combustion, Yale University, New Haven, Conn. For information write Combustion Symposium, Mason Lab., Yale U., 400 Temple St., New Haven 11, Conn.

August 20-21

National Telemetering Conference, sponsored jointly by IRE, AIEE, IAS and ISA, Ambassador Hotel, Los Angeles, Calif. For information write D. M. Cullar, Farnsworth Electronics Co., 3702 E. Pontiac St., Ft. Wayne, Ind.

August 21-24

1956 Western Electronic Show and Convention, Pan-Pacific Auditorium, Los Angeles, Calif.

August 22-Sept. 1

23rd Annual (British) National Radio Show sponsored by Radio and Electronic Component Manufacturers Federation, Earls Court, London, England.

August 27-29

11th annual meeting of Association for Computing Machinery at Westwood Campus, University of Calif., Los Angeles, Calif. For information write Assoc. for Computing Machinery, Box 3251, Olympic Sta., Beverly Hills, Calif.

August 27-31

7th Annual Infrared Spectroscopy Institute, Fisk University, Nashville, Tenn.

September

8th International Congress for the History of Science, Milan or Florence, Italy. For information write Pierre Sergescu, Secretary of Union, 7 Rue Daubenton, Paris 5e, France, or G. Ucelli, IUHS, Via Cappuccio 7, Milan, Italy.

September 5-13

9th International Congress of Applied Mechanics, University of Brussels, Brussels, Belgium. For information write Secretary, The American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

September 9-12

National Meeting of American Institute of Chemical Engineers, William Penn Hotel, Pittsburgh, Pa. For information write American Institute of Chemical Engineers, 25 W. 45th St., New York 36, N. Y.

September 9-16

15th International Congress of Pure and Applied Chemistry, International Union of Pure and Applied Chemistry, Lisbon, Portugal.

September 10-12

Fall Meeting of American Society of Mechanical Engineers, Cosmopolitan Hotel, Denver, Colo. For information write American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

September 10-12

Information Theory Symposium sponsored by Institute of Radio Engineers on campus of Massachusetts Institute of Technology, Cambridge, Mass.

September 10-17

Symposium on Reliable Electrical Connections sponsored by RETMA on campus of University of Pennsylvania, Philadelphia. For information write RETMA Engineering Dept., 11 W. 42nd St., New York 36, N. Y.

September 14

International Conference on Fatigue of Metals, sponsored by the Institution of Mechanical Engineers, London, England. For information write, Secretary, Institution of Mechanical Engrs., 1 Birdcage Walk, London S.W. 1, England.

September 15-23

4th International Instruments and Measurements Conference and Exhibition organized by the Royal Academy of Engineering Sciences and the Swedish Association of Technical Physicists, will be held in Stockholm, Sweden. For information write Sven Malstorm, P.O., Box 12035, Stockholm 12, Sweden.

September 16-21

130th National Meeting of the American Chemical Society, Atlantic City, N. J.

September 16-22

2nd Pacific Area National Meeting of the American Society for Testing Materials, Statler Hotel, Los Angeles, Calif.

Sept. 17-21

11th Annual Instrument Society of America Conference and Exhibit, New York Coliseum, New York, N. Y. For information write William H. Kushnick, ISA, Granite Bldg., 313 Sixth Ave., Pittsburgh 22, Pa.

September 20-21

IRE Professional Group on Nuclear Science 3rd Annual Meeting, Mellon Institute Auditorium, Pittsburgh, Pa.

September 23-26

Petroleum-Mechanical Engineering Conference, sponsored by American Society of Mechanical Engineers, Conrad Hilton Hotel, Dallas, Texas.

September 24-25

Industrial Electronics Conference, sponsored by Institute of Radio Engineers and American Institute of Electrical Engineers, Hotel Manger, Cleveland, Ohio.

September 24-28

Joint committee for Automatic Control of German Association of Electronic Engineers, (VDE) and German Engineers Society (VDI) Conference on Automatic Controls, Heidelburg, Germany. For information write Verein Deutscher Electrotechniker (VDE) Osthofenplatz 6, Frankfurt 2/main, West Germany.

September 30-October 2

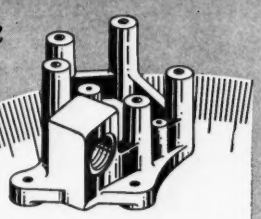
Fall convention and Co-Exhibit of American Congress on Surveying and Mapping and American Society of Photogrammetry, Shirley-Savoy Hotel, Denver, Colo.

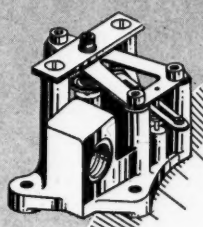
November 26-30

Third International Automation Exposition, New York Trade Show Building, 500 8th Ave., New York, N. Y. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Penna.

HEISE GAUGES

The Standard of the World

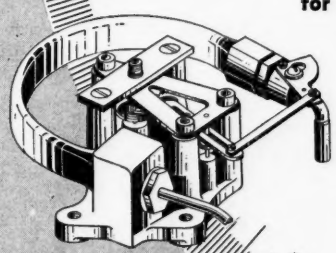


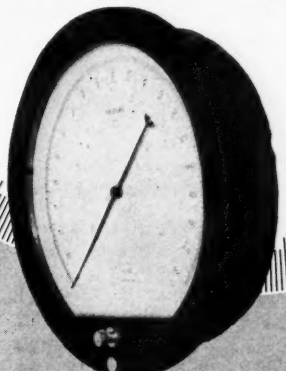


Integration In Design

The inherent stability of the Heise Gauge movement and the elimination of significant hysteresis effect in the integrally mounted Bourdon Tube give. the Heise Gauge its ability to indicate faithfully the most minute pressure variations. The scientific design of the Heise Bourdon Tube section and its weldless construction from carefully selected and heat treated metals is an exclusive Heise feature.

Custom designed to meet your specific needs, this gauge will register precisely for liquids, gases or mercury. Convenient adjustment of the dial may be used to compensate for barometric changes.





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15 to 20,000 P.S.I.

DIAL SIZES
8½" — 12" — 16"

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BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **52** on inquiry card.

INSTRUMENTS and AUTOMATION

New Instruments

CONTENTS OF THIS DEPARTMENT

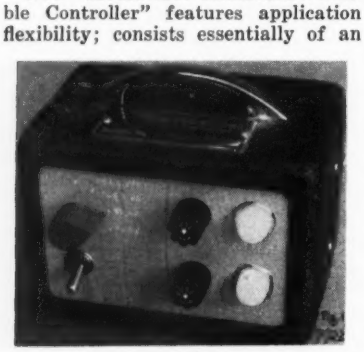
Amplifiers 1383
Computing 1362
Counting 1360
Data Processing 1362
Dimensional Gaging & Inspection 1374
Electrical Components 1384
Electrical Instruments 1379
Electrical-instrument Accessories 1381
Electrical Testing 1377
Electromechanical Components 1388
Electronic Components 1386
Electronic Instruments 1379
Flow-rate 1358
Laboratory Equipment 1366
Level 1358
Mechanical Components 1392
Mechanical Testing 1376
Miscellaneous 1399
Motors 1389
Nucleonics 1366
Power Supplies 1382
Process Measurement & Control 1352
Rectifiers 1383
Shop Equipment & Supplies 1372
Speed 1360
Temperature 1356
Time 1360
Valves, etc. 1394
Volume Level 1358
Weighing 1358

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 1433

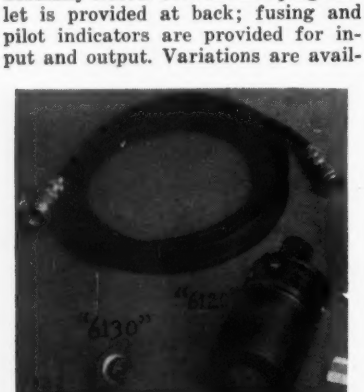
PROCESS MEASUREMENT and CONTROL

MINIATURE CONTROLLER

New "Model 6140 Miniature Portable Controller" features application flexibility; consists essentially of an



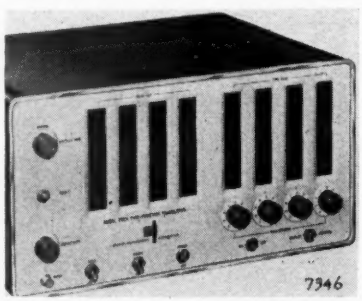
ultrasensitive electronic switch; will control up to 500 watts of power, either delivered at 115 vac 60 cps, or switched by its internal contacts. Rotary switch allows rapid panel selection of any of four output functions: power normally on or normally off, or switching normally open or normally closed. Convenience plug outlet is provided at back; fusing and pilot indicators are provided for input and output. Variations are available, including function selector switch lock to prevent tampering, also a reduced cost model with a single output function. ★ Various pickups include "Model 6130 Photo-Electric Detector," an ultra-miniature element of high sensitivity; and "Model 6120 Proximity Detector" for counting, liquid-level control and numerous other uses.—*Autron Engineering, Inc.*, 1254 *W. 6th St., Los Angeles* 17, *Calif.*



For more information circle **201** on inquiry card.

DIGITAL INDICATOR FOR PROCESS VARIABLES

New 'Model 202A Time-Function Translator" makes possible direct measurement of any electrical, me-

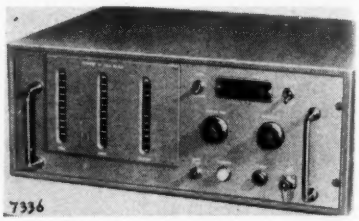


chanical or optical events which can be converted into a varying voltage: it permits direct read-out of unknown values by automatically translating one function of time into another function of time. It automatically translates calibration factor of various pickups to provide direct read-out. It is said to be ideally suited for tachometer applications and for use with turbine-type flow measuring devices which generate pulses directly proportional to rate of flow. Many other process and machine applications will suggest themselves.—*Computer-Measurements Corp.*, 5528 *Vineland Ave., North Hollywood, Calif.*

For more information circle **202** on inquiry card.

DIGITAL INDICATOR FOR PROCESS VARIABLES

New "Model 309 PTF Digital Computer," specifically designed for use with the frequency signals from mak-

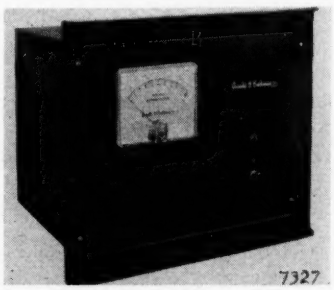


er's "Vibrotron" electronic gages in advanced data processing systems, is of frequency-counter type; is small (19" wide for standard relay rack mount) and low-priced. It indicates pressure, temperature and flow directly in numbers from 000 to 999 in steps of 1, thus providing a percentage type indication. Performance is read instantly and no external translation is required. For example, as pressure goes up at sensing point, numerical read-out is shown as an exact percentage increase. New computer can be used in conjunction with a printer or electric typewriter.—*Byron Jackson Electronic Div., Borg-Warner Corp., Los Angeles* 54, *Calif.*

For more information circle **203** on inquiry card.

GAS ANALYZER

New "Model 7C" thermal conductivity type gas analyzer can be used to measure a number of process



stream gases such as carbon dioxide, hydrogen, ammonia, etc. Instruments are designed individually to meet requirements of each application; are available with single or multiple ranges. With a choice of three outputs, virtually any recorder or indicator can be used. Standard output is 0-5 mv dc; analyzer can also be supplied with an auxiliary amplifier for current output or with an electro-pneumatic transducer for air output.—*Arnold O. Beckman, Inc.*, 1020 *Mission St., South Pasadena, Calif.*

For more information circle **204** on inquiry card.

DIGITAL CONVERSION KIT

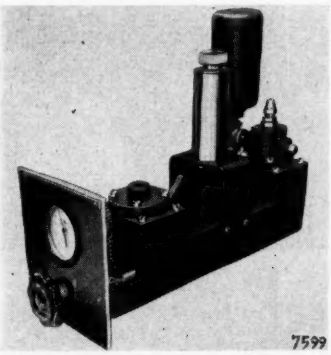
New "packaged" digital conversion of Minneapolis-Honeywell "Series 156 Circular Scale Indicators" is designed

for use in automatic data logging, data processing, and control systems. All conversion equipment is contained within the original instrument housing. Optional integral damping device suppresses input level fluctuations from transmitters without affecting speed of balance. Decimal digit output data are suitable for direct input to IBM Summary Punch, electric typewriter, Clary printer, etc., Power required is less than 200 watts.—*Hanson Gorill-Brian, Inc., 85 Hazel St., Glen Cove, N. Y.*

For more information circle **205** on inquiry card.

PNEUMATIC RATIO RELAY

New "Model 3-15 Ratio Relay," for pneumatic control applications, produces a true linear change in out-



put when using "suppressed" ranges such as 3-15 psi; enables operator to adjust ratio between input and output signals in control systems such as combustion fuel-to-air, gas mixing, proportional chemical feeding, etc. Features: (1) true ratioing around 3 psig input and output bias pressures; (2) precision fulcrum drive for exact ratio adjustment; (3) compatible with any pneumatic signal system whose range is between 0 and 20 psi; (4) simple method of altering suppressed scale setting if desired, between 0 and 6 psig.—*Hagan Corp., Hagan Bldg., Pittsburgh 30, Pa.*

For more information circle **206** on inquiry card.

SOAKING PIT COVER CONTROL

New system for opening and closing soaking pit covers from a crane operates over existing power sys-

Compact, Practical Gauges For
Moderately Reduced Pressures

DUBROVIN VACUUM GAUGES

- Range: 0.2 mm To 20 mm of Hg
- Two Sensitivities Available
- Far More Sensitive Than Mercury Manometer
- Pyrex-Brand or Soft-Glass Construction
- Table or Wall Mounting

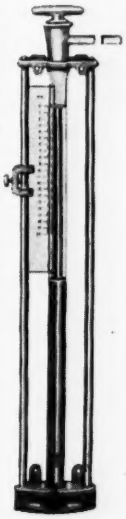
No. 1451C. Table Mounting

The Dubrovin Gauge indicates the pressure continuously, may be left in the system indefinitely, and is not damaged if the line is suddenly opened to atmospheric pressure. It is simple to install and convenient to use. A typical application for which it has proved especially convenient is the filling of tubes with gas at a specified pressure, as in the luminous-tube industry. It is useful wherever a sensitive gauge of this range is needed.

There are two basic types, one 9 times and the other 6 times as sensitive as a mercury manometer. Because of this "magnifying factor", the gauge is as sensitive as a manometer which uses a liquid of low density, but has the advantage of using mercury which dissolves very few organic or inorganic vapors and which requires no conversion factor. Unlike mechanical or optical magnifying devices, any small errors due to capillarity, adhesion, etc., are not magnified. The smallest division on the 9-to-1 type is 0.2 mm and on the 6-to-1 type is 0.5 mm of Hg. Fractions of these values may be estimated. Both types are available with Pyrex-brand or soft glass in either a table or wall mounting.

The Dubrovin Gauge consists of a stainless-steel cylinder, of small diameter and closed at one end, floating vertically in mercury with its open end submerged and with the air evacuated from the chamber thus formed. The outer tube, in which the cylinder and mercury are enclosed, is of glass mounted in a metal frame and connected to the vacuum line. An adjustable scale on the metal frame is read by an indicator at the top end of the floating cylinder.

To set up, the gauge is first evacuated by a good mechanical pump to about 1 micron while being supported on its side so that air will be removed from the floating cylinder. It is then set upright and the scale adjusted until the index reads zero. The gauge may then be opened to atmospheric pressure and installed in any vacuum line, care being taken not to incline it such that air re-enters the float.



No. 1451H. Wall Mounting

Cat. No.	Pressure Range mm of Hg	Magnifying Factor	Merc. Req'd, Lbs.	Material of outer tube	Mounting	Each
1451C	0.50 to 20	6	1	soft glass	Table	$44.50
1451D	" " "	"	"	Pyrex Brand	"	44.50
1451G	" " "	"	"	soft glass	Wall	44.50
1451H	" " "	"	"	Pyrex Brand	"	44.50
1451E	0.2 " "	9	2¼	soft glass	Table	52.50
1451F	" " "	"	"	Pyrex Brand	"	52.50
1451J	" " "	"	"	soft glass	Wall	52.50
1451K	" " "	"	"	Pyrex Brand	"	52.50

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1515 Sedgwick Street, Dept. B, Chicago 10, Illinois, U.S.A.
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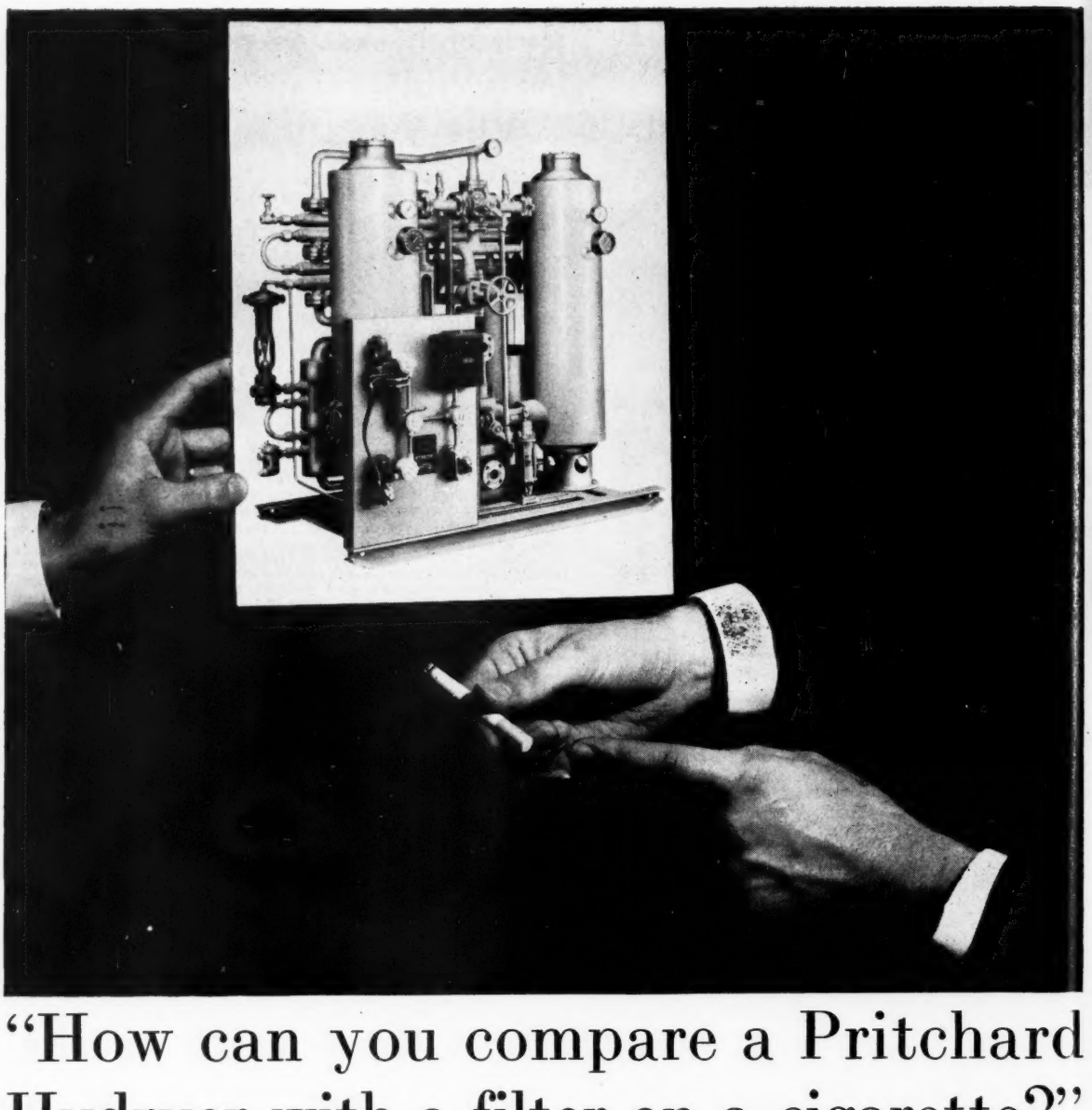


"How can you compare a Pritchard Hydryer with a filter on a cigarette?"

"You know how a cigarette filter removes unwanted materials in your smoke? Well, the Pritchard Hydryer removes or 'grabs' the moisture in the air we use to operate our instruments."

"Is this 'grabbing' action the same in both?"

"Not exactly. You see the 'grabbing' action, as you call it, in the Hydryer is accomplished by an adsorption process in which solid adsorbents are used to reduce the moisture content of the instrument air stream. In a cigarette, the filtering is purely a mechanical action."

"Why are we so interested in dry air for our instruments?"

"First, because our precision instruments must have exceptionally dry air to operate accurately, and second, because moisture in our air lines can cause corrosion and freeze-ups in cold weather."

"How about the capacity of our Hydryer?"

"Right now we're getting air delivered continuously with a dew point temperature not in excess of —20°F.; capacity, 420 CFM at standard conditions; pressure 100 psig; temperature, 80°F."

"No more frozen or corroded air lines for us then."

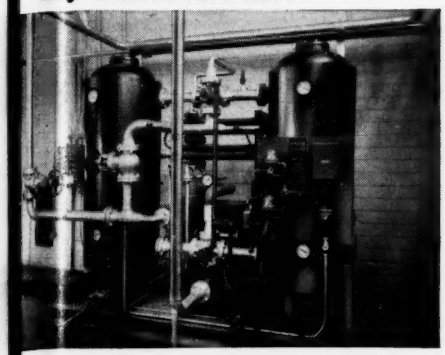
"Not with our Pritchard Hydryer."

J. F. PRITCHARD & CO. OF CALIFORNIA
4625 Roanoke Parkway, Kansas City 12, Mo.

For more information circle **54** on inquiry card.

"How can you compare a Pritchard Hydryer with a filter on a cigarette?"

The Pritchard HYDRYER®
Unmatched for Continuous Delivery of Dry Instrument Air!



Precision automation instruments demand a constant source of extremely dry air for accurate operation. The Pritchard HYDRYER has proved its ability to deliver air that is free from damaging moisture. Only in a Pritchard HYDRYER do you get all of these features:

- NO WASTE—100% of all air or gas entering the HYDRYER is dried without loss.
- FULL LINE PRESSURE REACTIVATION — Pressuring and depressuring of adsorbers between cycles is eliminated.
- PURGING ELIMINATED — The Type A HYDRYER uses inlet main air streaming for reactivation.
- LONGER ADSORBENT LIFE.
- REACTIVATED GAS PRE-HEATED
- NO MOVING PARTS
- SIMPLIFIED OPERATION
- REDUCED EQUIPMENT AND LINE SIZES

. . . plus many more advantages.

SEND FOR BULLETIN

Write today on your company letterhead for Pritchard bulletin No. 16.0.081. This complimentary bulletin tells you the many ways HYDRYERS can help you solve your instrument air problems.

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REPRESENTATIVES IN PRINCIPAL CITIES FROM COAST TO COAST

For more information circle **54** on inquiry card.

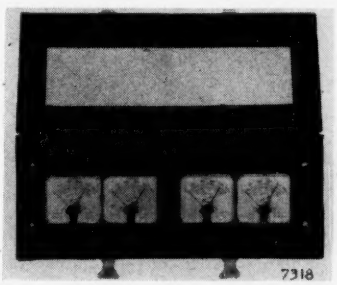
NEW INSTRUMENTS

tem; will select and operate up to fifty separate covers from a soaking pit crane. Installation can be made for a few or many soaking pits. Advantages include time-saving, safety, increased production, improved coordination and better teamwork. Specific feature is that pit cover can be opening while crane is approaching pit.—*Femco, Inc., Irwin, Pa.*

For more information circle **207** on inquiry card.

WEATHER-TIGHT CABINETS

New "Weather-Tight" case can be supplied for thermal monitors and other "Polypoint" electric-contact-

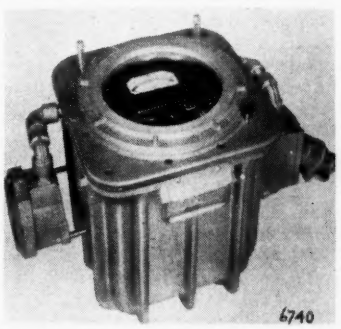


type indicating controls. One to four "Simplytrol" or "Versatrol" controls can be included.—*Assembly Products, Inc., Chesterland, Ohio.*

For more information circle **208** on inquiry card.

GAS ANALYZER AND ALARM

New self-contained portable analyzer and alarm system for combustible gases, for use in or near hazardous locations, features continuous sampling system operated by motor-

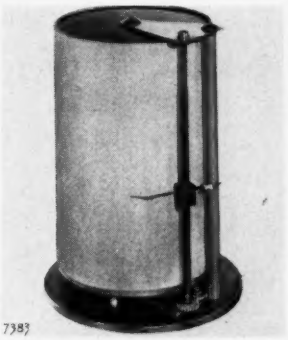


driven pump mounted inside unit; visual and audible "high gas" signals; easily-read scale calibrated 0 to lower explosive limit, showing gas or vapor concentration at all times; built-in "trouble-indicating" circuit.—*Davis Instruments, 47 Halleck St., Newark 4, N. J.*

For more information circle **209** on inquiry card.

OPERATIONS RECORDER

New "Model MD-Jr" features slightly spiral tracings (⅛" per drum rotation) whereby stylus produces

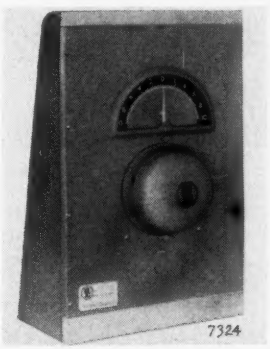


more than 400 linear inches on an easily-filed 6"x13" chart. On model with 24-hour drum rotation, chart speed is more than ½" per hour. Corresponding periods of all hours and days throughout one entire month can be compared directly above or below one another. Signal response to 5 per second. Motor 115 v 60 cps. Coil (as ordered) 6 to 120 vac or dc or 5000 ohms for electronic use. Other kymographs with speeds from 4 minutes to 5 years per drum rotation.—*Gorrell & Gorrell, Haworth, N. J.*

For more information circle **210** on inquiry card.

PROCESS REFRACTOMETER

New "Differential Refractometers," for continuous monitoring of process plant streams, continuously measures



difference in refractive index between a flowing liquid sample and a reference liquid, thus monitoring changes in sample. It comprises a sealed optical system, photocell detection, temperature compensation and a null balancing system for maximum accuracy. It is explosion-proofed. Sample cell is readily accessible. Results can

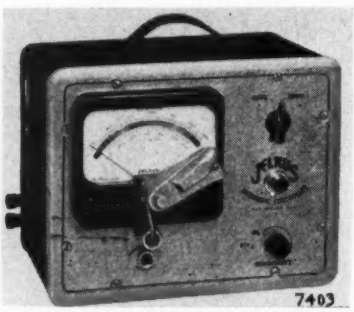
be read directly from a dial or a remotely located recorder. Three models with ranges of limiting sensitivities covering 0.0001, 0.00001, 0.000002. Accuracy is better than 0.5%.—*Barnes Engineering Co.*, 30 *Commerce Rd., Stamford, Conn.*

For more information circle **211** on inquiry card.

TEMPERATURE

TEMPERATURE CONTROLLER

New "Automatic Controlling Pyrometer" utilizes a photoelectric prime relay imposing no mechanical or elec-



trostatic or electromagnetic force on pointer. Load relay has 15-amp rating. Choice of thermocouples and ranges. Instrument will always fail safe (including TC failure). TC circuit resistance compensation assures accuracy over entire scale.—*The Jelrus Co., Inc.*, 136 *W. 52nd St., New York* 19, *N. Y.*

For more information circle **212** on inquiry card.

MAX-MIN THERMOMETER

New "Model 581-F Pandux Recording Maximum-Minimum Thermometer" features a replaceable paper

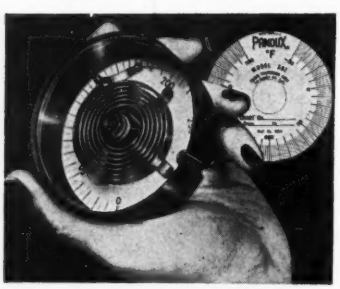
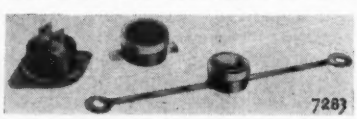


chart on which temperature excursion is permanently recorded; comes in two ranges: −50°F to 250°F or −50°C to 100°C.—*Pacific Transducer Corp.*, 11836 *West Pico Blvd., Los Angeles* 64, *Calif.*

For more information circle **213** on inquiry card.

EQUIPMENT THERMOSTAT

New "Klixon 201 Series" is said to be "ideal for original equipment manufacturers who are concerned with

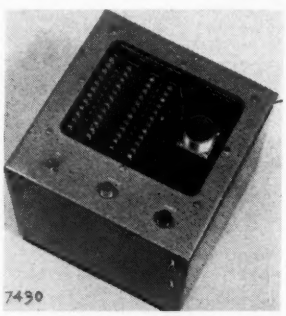


volume usage suitable for an engineered thermostat application," features factory-preset temperature settings from 80°F to 300°F, positive snap-action operation, and low cost. Ratings: 10 amp resistive, 110 vac, 6,000 cycles; 5 amp resistive, 240 vac, 50,000 cycles.—*Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.*

For more information circle **214** on inquiry card.

TC REFERENCE JUNCTION

New "Model RJ-1 Thermocouple Reference Junction," for use with multi-channel temperature measuring

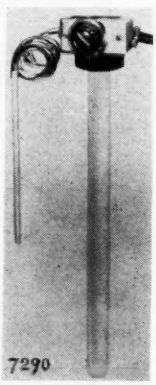


systems, provides a thermostatically-controlled RJ, obviating need for cold-junction compensation and ice-bath maintenance; includes 24 TC's with choice of I-C, C-A or C-C in each of twelve independent circuits. At ref temp of 150°F, for which TC tables are available, rated accuracy is 0.5 F deg. under normal ambient conditions.—*Pace Engineering Co.*, 6914 *Beck Ave., North Hollywood, Calif.*

For more information circle **215** on inquiry card.

HEATER-THERMOSTAT

New QT" single-unit immersion heater and thermostat, prewired and ready to be connected into any available circuit, is suitable for use in both small plating tanks and in an independent series in large tank installations. In large-area tanks, individual portable units assure uniform heat distribution. Worn-out elements are easy to replace.—*N. J. Thermex Co., Inc.*, 533 *Bergen St., Harrison, N. J.*



For more information circle **216** on inquiry card.

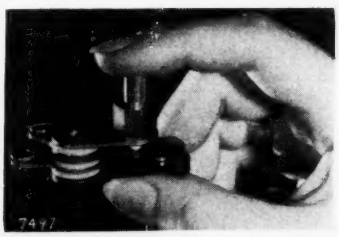
TEMPERATURE INDICATOR

New "Model 385-3L," an adaptation of maker's "Model 385," features three primary elements which can be placed in different locations, and a selector switch. One element might be put in a refrigerator's freezer compartment, another in a central position in box, and the third in bottom area of refrigerator. Range −50°F to 70°F.—*Simpson Electric Co.*, 5208 *W. Kinsie, Chicago* 44, *Ill.*

For more information circle **217** on inquiry card.

SNAP-ACTION THERMOSTAT

New "Uni-Therm" thermostat designed for appliances requiring positive snap-action at a predetermined



temperature will "remake" with a predetermined differential; features quick thermal response by reason of metal-to-metal contact with heated surface; is available in any calibration up to 550°F; rating 1500 watts on 115 or 230 vac; limited dc ratings.—*Westinghouse Electric Corp., P. O. Box* 2099, *Pittsburgh* 30, *Pa.*

For more information circle **218** on inquiry card.

PRESSURE

MULTI-PRESSURE CALIBRATOR

New Pressure Calibrator will perform many functions. As a calibrating unit, it will supply one or several

pressures to one or more instruments to be calibrated. Pressures can be varied at will. Depending on mode, selection is accomplished either by electrically or by manually operating valves. As an indicator, it will continuously and accurately monitor one pressure on each channel. Its precision dial manometer can always be switched into any channel for a precise indication, or for exact balancing

MALLORY

Unique "snap together" cell design brings new economy to Mallory Mercury Batteries . . . now ready in "B" battery voltages at low cost.*

Higher Voltage and Lower Costs Available in New Mallory Mercury Batteries

MALLORY MERCURY BATTERIES—with their exceptionally long shelf and service life—are now economically practical as a miniature power source at "B" battery voltage ratings. The secret is a unique new construction. Hermetically sealed unit cells are stacked together at the factory to make miniature batteries of any required voltage, in varied physical shapes. Automated production, under precise control, makes it possible for these new batteries to offer hourly operating costs substantially less than usual miniature zinc-carbon types.

In reliability, the Mallory mercury batteries far exceed conventional types. Shelf life is five times as long. Service life, too, is much greater. On continuous drain in a transistor radio, for example, the Mallory mercury battery outlasts three ordinary batteries. A unique feature of the mercury cell system is that it can be miniaturized without sacrifice of dependability or uniformity.

Their constant-voltage, constant-current discharge makes these batteries ideally suited for transistor circuits. Because of their accurate, steady voltage, they are useful in instrument circuits as a voltage reference source, and as a bias cell for vacuum tube circuits.

New Mallory mercury batteries are supplied in 15, 22½ and 45 volt ratings, in the same case sizes as standard carbon miniature batteries. They can also be made readily in other voltages and case sizes, to your own requirements. For complete data, write or call Mallory today.

**Patent applied for*

Parts distributors in all major cities stock Mallory standard components for your convenience.

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Tuning Devices • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

Expect more . . . get more from

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., BATTERY DIV., NORTH TARRYTOWN, N.Y.

For more information circle **55** on inquiry card.

of several pressures. A special design feature, which finds particular use in test facilities, permits each channel to be changed from a monitor to a calibrator by a single switch. Many models available, including "completely custom" models.—*Lee Engineering Co., PO Box 3092, Ventura, Calif.*

For more information circle **219** on inquiry card.

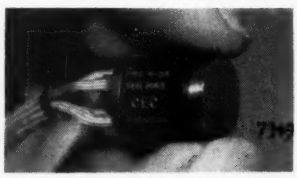
PRESSURE PICKUP

New "Type P-478 Pressure Transducer," made of stainless steel, features flush diaphragm integral with body, allowing pickup to be mounted in aircraft skins, pressure vessels, pipes, etc., without obstructing flow or causing turbulence. Output voltage is linear, is substantially higher than that of strain-type pickups. Deflection-measuring element is maker's "Linear Variable Differential Transformer." No mechanical linkages, hence no errors due to friction and wear. Natural frequencies from about 2000 cps for lowest range to above 10,000 cps for ranges above 300 psi. Sensitivity for 100-psi unit is about 10 mv/v full-scale or 1 mv/psi at full input of 10 v at 10 kc.—*Schaevitz Engineering, P. O. Box 505, Camden 1, N. J.*

For more information circle **220** on inquiry card.

HI-TEMP PRESSURE PICKUP

New "Type 4-316" pressure pickup is said to "more than double the existing temperature range for this type

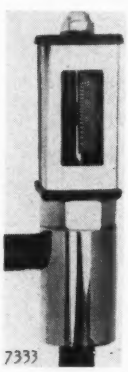


of transducer," operates continuously up to 600°F; is available in both gage and differential types; weighs 15 grams with its 30" of insulated permanently-attached 4-conductor cable.—*Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.*

For more information circle **221** on inquiry card.

FLOW-RATE, VOLUME LEVEL, WEIGHING

ARMORED FLOW INDICATOR

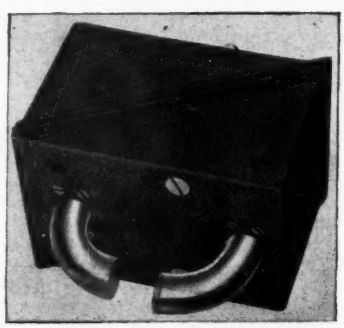


New "Model 3602" armored flow indicator, for purge service or flow-rate indication of hazardous fluids at pressures up to 1500 psig and temperatures to 400° F, has no glass parts in contact with metered fluid: flow is indicated by tubular follower magnetically coupled to extension on tapered plug in fixed orifice which measures flow-rate. Positive O-ring seal eliminates stuffing boxes. Standard flow rates from 1.5 to 180 gph of water in single meter body by five plug-and-orifice sets. Easily disassembled for cleaning or range change without removal from pipe-line. Stainless steel, carbon steel or brass. —*Brooks Rotameter Co., Lansdale, Pa.*

For more information circle **222** on inquiry card.

BIN LEVEL CONTROL

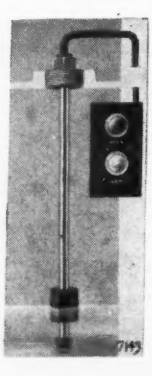
New "No. A-135-134 Photelectric Control Unit" uses curved Lucite rods to conduct light around corners for bin level control of granular materials, flakes, powders and small dry solids of all kinds. Light source and phototube are both mounted in "sensing head." Installation merely requires slots in bin wall for Lucite



rods and mounting holes for attaching head. Gaskets can be used to make a tight seal.—*The Autotron Company, Box 722-CC, Danville, Ill.*

For more information circle **223** on inquiry card.

LIQUID LEVEL INDICATOR

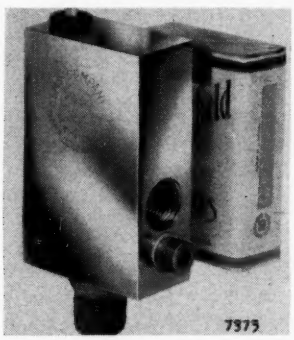


New "Model LI-800 Level Indicator" is easy to install; can indicate high and/or low level and, if desired, any number of intermediate levels. As foam plastic float moves up or down indicator stem and passes preselected points, hermetically-sealed switches are actuated. These can flash lights or sound horns or, through relays, command pumps or other power-driven equipment.—*Gems Company, 64 Welles Drive, Newington, Conn.*

For more information circle **224** on inquiry card.

FLOW INDICATOR & SWITCH

New "Model FI-900" indicator is capable of reliably detecting flow as small as 1 gph. Flow through unit actuates a switch that can be used to actuate a pilot light or other warning device or—with suitable relays—to operate a control element. Instrument operates on a pressure differen-

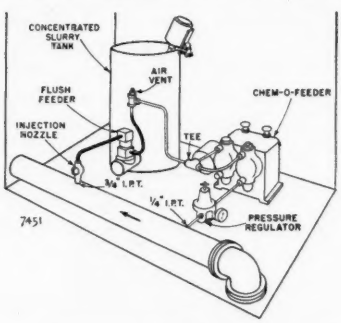


tial of less than ½ psi. Standard models are offered for ⅜" pipe and tube connections; ⅛" and ¼" available on request. Operation on all standard models can be set at any desired point from 5 to 50 gph.—*Gems Co., Newington, Conn.*

For more information circle **225** on inquiry card.

FLUSH-FEEDER

New Flush-Feeder handles high-concentration slurry solutions and corrosive liquids. With it, a fairly



small make-up tank can often hold enough slurry for several days' operation, minimizing operator surveillance. Slurry cannot enter primary displacement cylinder. Only water (or compatible fluid chosen for flushing) passes through reagent ends of Duplex Chem-O-Feeder.—*Proportioneers, Inc., 345 Harris Ave., Providence, R. I.*

For more information circle **226** on inquiry card.

INDUSTRIAL SCALES

New models represent a major expansion of "Hydroscale" line, which now includes 110 models, with capac-

FREQUENCY STANDARDS

TYPE 50

AVIONIC
FREQUENCIES
PRECISION FORK

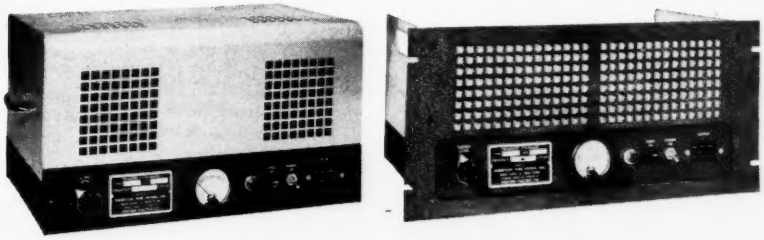
FREQUENCIES
240–400–500–1,000 cy.

ACCURACIES
Type 50 ±.02% (—65° to 85°C)
Type R50 ±.002% (15° to 35°C)

Requires double triode and 5 pigtail components

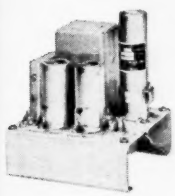
Size, 1" diameter x 3¾" high
Weight, 3.5 ounces

POWER
75 Watt FREQUENCY STANDARD
TYPE 211C



FREQUENCIES: .....50 to 1,000 cycles
ACCURACY: ..±.002% (+15° to +35°C)
OUTPUT: .....115V, 75 Watts
INPUT: .....110V, 50 to 75 cycles
SIZE: with cover....10"x17"x9" high
PANEL model,..10"x19"x8¾" high
WEIGHT: .....25 pounds

INDUSTRIAL



FREQUENCY STANDARD
TYPE 50L

FREQUENCIES
50–60–75 or 100 cy.

ACCURACIES
TYPE 50L
±.02% (—65° to 85°C)
TYPE R50L
±.002% (15° to 35°C)

INPUT: 150 to 300V, B (6 V at .6 amps.)
OUTPUT: .....2V into 200,000 ohms.
SIZE:..3¾"x4½"x5½" high. Wgt., 2 lbs.

This organization makes frequency standards within a range of 30 to 30,000 cycles. They are used extensively by aviation, industry, government, (armed forces) where maximum accuracy and durability are required.

American Time Products Inc.
580 Fifth Avenue, New York 36, N. Y.

American Time Products, Inc.
580 Fifth Ave., New York 36, N. Y.
Gentlemen: Please send details on your Type_____
Name_____
Company_____
Address_____
City_____

For more information circle **56** on inquiry card.

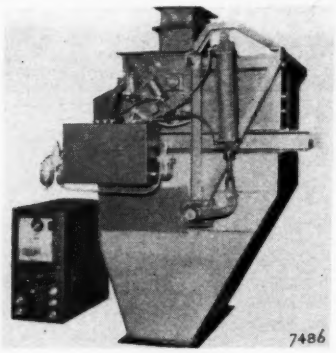
NEW INSTRUMENTS

ities from 500 to 200,000 lbs.—*Hydroway Scales, Inc.*, 20624 *W. 8 Mile Rd., Detroit* 19, *Mich.*

For more information circle **227** on inquiry card.

BATCHING SCALE

New "Model 700N Batching Scale" employs a unique rotary type feeder for charging a gateless tipping type weigh bucket. A cycle timer automatizes the weigh bucket's charging and discharging. "Model 700N" has no



knife-edge pivots, therefore can handle millions of weighings without any loss in scale accuracy or sensitivity and is especially suitable when handling products which are dusty, corrosive or abrasive.—*Thayer Scale & Engineering Corp., Rockland, Mass.*

For more information circle **228** on inquiry card.

TIME, SPEED, COUNT

7-DAY TIME SWITCH

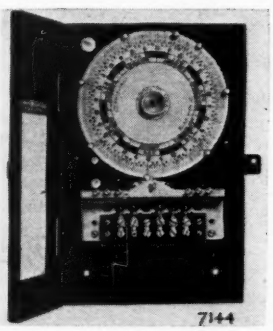
New "TSA-40" heavy-duty general-purpose time switch, featuring greater reliability at less cost than its pre-

decessor ("T-27"), is suitable for indoor and outdoor use. "Telechron" 4-watt motor, with permanent silicone-grease lubricant sealed-in, has positive operation from −50°F to 150°F. Switch is furnished with either a plain dial for fixed time setting or an astronomic dial for dusk and dawn schedules. One or more days can be skipped during a week of operation.—*Instrument Dept., General Electric Co., West Lynn, Mass.*

For more information circle **229** on inquiry card.

7-DAY TIME SWITCH

New "5B" 7-day time switch automatically regulates a complex weekly program involving from 1 to 6 daily on/off operations: heating, ventilating, air-conditioning; attic fan; refrigerator defrosting; factory flood-



lights; hall and stairway protective night lights; etc. Each day's schedule (which can be varied or omitted) is independent of every other day's schedule.—*General Controls, Skokie, Ill. or Glendale, Calif.*

For more information circle **230** on inquiry card.

STOP CLOCKS

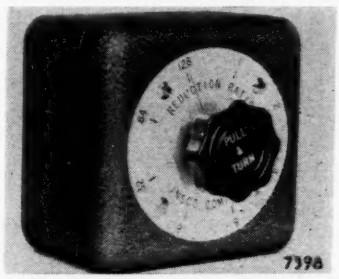
New "K15300 Series" stop clocks with electrical reset, equipped with maker's "5600 Series Chronometrical-

ly Governed D.C. Motors," are accurate to 0.20% of reading plus or minus 20 ms from −55°C to 85°C, over wide voltage variations. Electrical reset permits local or remote control or automatic operation for measuring successive time intervals. Clocks can be used successfully for calibration, test rigs, etc.—*A. W. Haydon Co., Waterbury, Conn.*

For more information circle **231** on inquiry card.

SPEED REDUCER

New "Step-Function Speed Reducer" is said to combine versatility of a continuously-variable speed drive

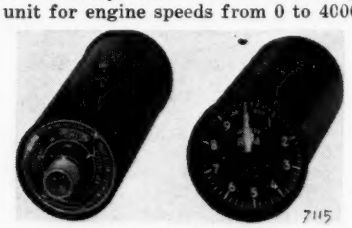


with positive drive and exact repeatability of a geared unit. Any of eight speed ratios can be dialed without stopping input drive shaft. Unit has torque capacity in excess of 30 ounce-inches and is recommended for input speeds up to 500 rpm. Reduction ratios up to 1500 to 1 are available.—*Insco Co., Div., Barry Controls Inc., Groton Mass.*

For more information circle **232** on inquiry card.

ELECTRIC TACHOMETER

New "Tachometer Indicator" is a hermetically-sealed remote-indicating unit for engine speeds from 0 to 4000

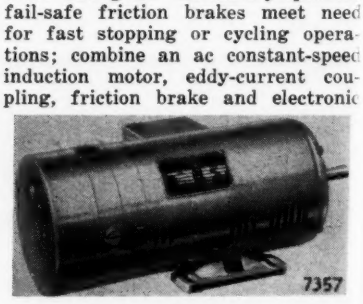


rpm; in a 2" case 4¼" long; weighs 0.9 lb; meets MIL-I-7098 and MIL-I-7186 and will withstand all basic environmental tests.—*Burton Mfg. Co., Colorado Ave. at 26th St., Santa Monica, Calif.*

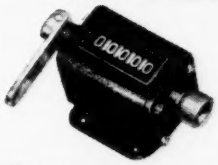
For more information circle **233** on inquiry card.

ADJUSTABLE-SPEED DRIVES

New "Adjusto-Spede" FHP drives with integral electrically-operated fail-safe friction brakes meet need for fast stopping or cycling operations; combine an ac constant-speed induction motor, eddy-current coupling, friction brake and electronic



Here's THE basic V-R "COUNTER-PACKAGE" for INDUSTRY...

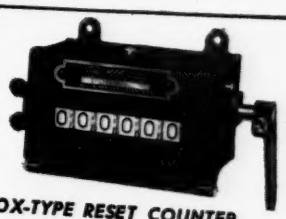


SMALL RESET COUNTER

A compact, rugged reset counter for moderate duty in parts inspection, quality control, conveyors, machine tools, light presses, etc.

Dimensions: 1¾" long, 1 19/64" high, 1 1/16" wide

Speed: Up to 1000 counts per minute.



BOX-TYPE RESET COUNTER

For punch press installations, conveyors, metal-working equipment, die casting, plastic-molding, rivet, spring and wire machining, or any installation requiring a heavy duty counter.

Dimensions: 4¼" long, 2 3/32" high, 3⅜" wide.
Speed: 500 counts per minute.

RESET MAGNETIC COUNTER

For remote indication of machine operation from plant to office.

Dimensions: 3 15/16" long, 2½" high, 1⅝" wide.

Speed: Up to 1000 counts per minute.

Coils: 110V-AC are standard. Other voltages are available. Panel mounting feature also available.

HAND TALLY

For quick spot-checks of production or performance.

Dimensions: 1 17/64" long (to end of reset knob), 1¾" deep, 2" high.

Counts one for each depression of the thumb lever, and resets to zero by a turn of the knob.

CLUTCH SPEED COUNTER

For checking to make sure that the machine is operating at the required R.P.M.

Dimensions: 3¼" long, ⅞" max. diameter. Non-Reset.

Internal clutch operates counter only when rubber tip is pressed against the shaft.

Here are 5 of the most widely used Veeder-Root Counters in industry . . . and they're immediately available from stock at leading Industrial Supply Distributors. There are Veeder-Root mechanical, electrical and manual counters for use in production recording and control, wage payment, time study work, quality control. In fact, you can profitably apply Veeder-Root Counters to every machine, operation, process or system in your plant. Ask your own Industrial Supply Distributor. Or write Veeder-Root Inc., Hartford 2, Conn.

Everyone can count on

VEEDER-ROOT

'The Name that Counts'

Insist on Standard

VEEDER-ROOT COUNTERS

from your

Industrial Supply Distributor

or write us on special problems

For more information circle **57** on inquiry card.

PALMER
MERCURY ACTUATED

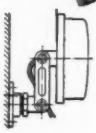
DIAL THERMOMETERS

in 3 types to suit any requirements

Full 4½" dial face. Stem can be placed at any angle and case can be rotated to any readable position.

1 **Rigid Stem Dial Thermometer** tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)

2 **Wall Mounted Dial Thermometer** with flexible connecting armor. Case adjustable to easy reading position.



3 **Flush Mounted Dial Thermometer** for panel mounting with flexible connecting armor.

All three types have a full 4½" dial face.

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensaton. Guaranteed Accurate 1 scale division.

for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.

Write for Catalog Information

PALMER
THERMOMETERS, INC.
Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory Recording and Dial Thermometers

For more information circle **58** on inquiry card.

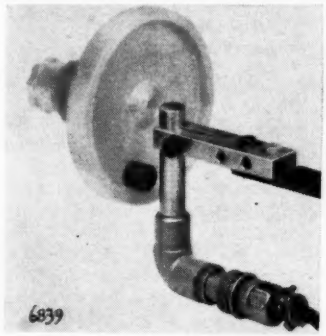
NEW INSTRUMENTS

control. Connection to power line is only wiring required. All drives have a continuous constant torque rating through a 25:1 speed range. Brake ratings 18 or 36 lb-in.—*Dynamatic Div., Eaton Mfg. Co., Kenosha, Wis.*

For more information circle **234** on inquiry card.

PROXIMITY SWITCH

New "Model MH-2" magnetically-operated high-speed switch is actuated by proximity of a magnetic field;



can be actuated by a transient magnetic field of only 8 milliseconds; provides a sharp make-and-break with no bounce at highest or lowest speeds. Speed limit 200 cycles per second; service life over 30 billion cycles. Contacts are sp-dt, rated at 5 amps non-inductive.—*Electronic Products Div., Post Machinery Co., Beverly, Mass.*

For more information circle **235** on inquiry card.

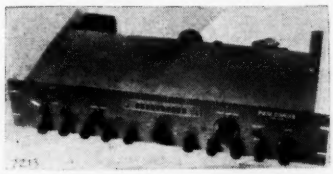
STROBE UNIT ACCESSORY FOR RATE-OF-TURN TABLE

New "Precision Strobe Unit" for maker's "Model C 181" rate-of-turn table is fired by a controlled frequency generated from the output of a precision tuning fork. Since it operates independently of line frequency, operator has a precise method of setting and monitoring rates during a test run. Accuracy of the strobe flash frequency is 0.01% or better at 20°C. Another advantage is strobe frequency divider, which permits operator to select either line- or fork-controlled frequencies at 15, 30 and 60 cps.—*Genisco, Inc.*, 2233 *Federal Ave., Los Angeles* 64, *Calif.*

For more information circle **236** on inquiry card.

VARIABLE-SCALE COUNTER

New "Type 1750," said to feature "a better method of displaying the count in a digital system, as well as



greatly improved operating characteristics," is applicable to any counting need whether for a preset counter, a burst counter, a scaler, or an adder. Each count is represented visually by means of a neon indicator and electronically in the form of a dc signal, thereby allowing unit to act also as a sorter, a pulse distributor, a converter, or a coding device. Counter input accepts 0.1-usec, 30-volt pulses, amplifies and standardizes them, and then applies these pulses to the grids of maker's beam switching tube where they are counted at speeds from push-button to 500 kc. Scale factors of 2 through 10 are available by turning a knob. Provision is also made for automatic zero reset without cycling.—*Burroughs Corp., Detroit* 32, *Mich.*

For more information circle **237** on inquiry card.

COMPUTING and DATA PROCESSING

MEMORY SYSTEM

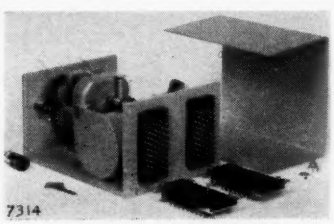
New "Elecom File Processor" reduces the contents of 1600 conventional file cabinet drawers to less than 3 cu ft of space; also feeds desired

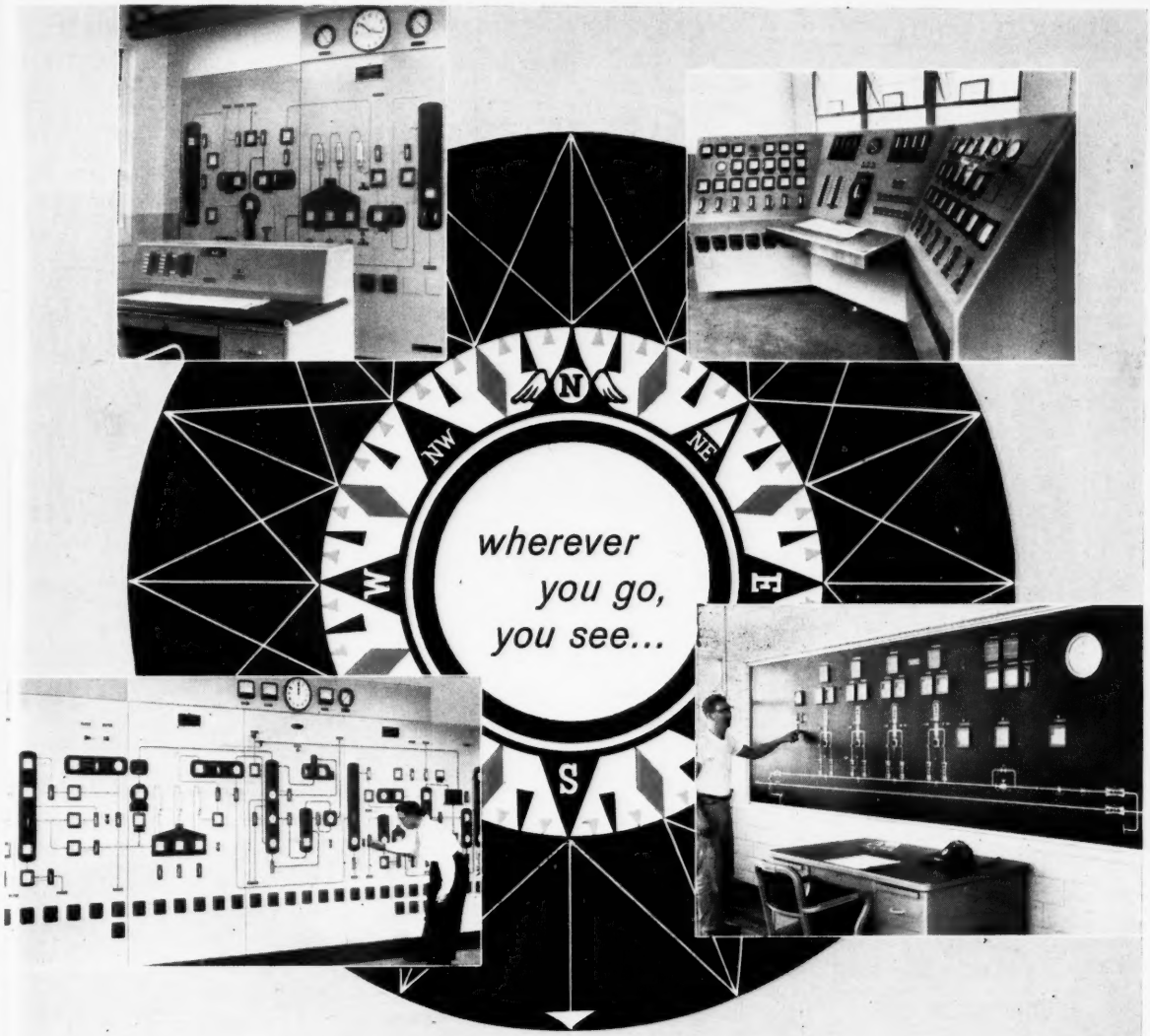
information via magnetic tape to a companion electronic computer. (The two units, sold or leased together or separately, are known as "Elecom 125 System.") New "File Processor" automatically sequences, selects, collates and separates information recorded on tape; can be used for billing, taking inventory, figuring salesmen's commissions and other routine functions.—*Underwood Corp.*, 1 *Park Ave., New York* 16, *N. Y.*

For more information circle **238** on inquiry card.

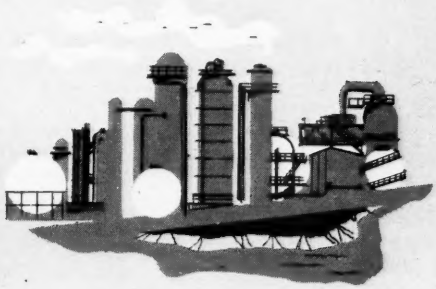
DRIFT COMPENSATION SWITCH

New Computer Drift Compensation Switch is primarily for use in electronic analog computers, to connect a single ac compensating amplifier in sequence to a number of d





Swartwout AUTRONIC® CONTROL SYSTEMS



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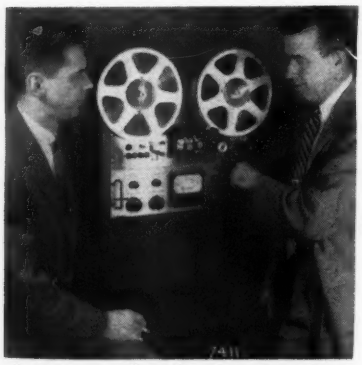
For more information circle **59** on inquiry card.

computing amplifiers for zero drift or offset compensation; has two poles; 60 or 80 make-before-break contacts per pole; sampling speeds from 3.5 to 4 rps; adjustable phasing between poles.—*Applied Science Corp., P. O. Box* 44, *Princeton, N. J.*

For more information circle **239** on inquiry card.

TAPE TRANSPORT

New "P-63-AX" tape transport mechanism is a "professional sound" rack-mount recorder with a panel size

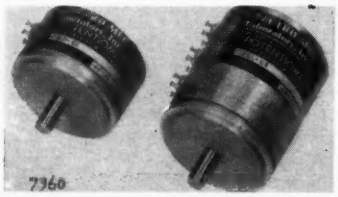


of 10½ x 19", using low impedance heads which match all maker's "PT-6, PT-63 and PT-7" amplifiers currently in service. It is said that "P-63-AX" will enable broadcasting and recording studios to bring their tape recording equipment up to industry's highest standards and save considerable cost of a new amplifier.—*Magnecord, Inc.,* 1101 *S. Kilbourn Ave., Chicago* 24, *Ill.*

For more information circle **240** on inquiry card.

COMPUTER VDR

New "Type 18 Ultra-Low Torque Potentiometer" is a voltage-dividing resistor for computer applications

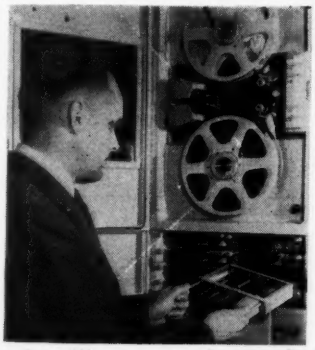


featuring a servo type mounting. Single and three-gang units pictured above are 0.97" and 1.97" long, respectively. Diameter is 1.75". Individual VDR cups are 0.500" long. Ganged assemblies up to 15 cups are available. Ball bearings, ABEC Class 5, and 18-karat gold slip rings facilitate operation with extremely small mechanical forces, 0.20 oz-in per cup normally, and as low as 0.050 oz-in in special cases. Available with resistance values up to 200,000 ohms; rating 2.2 watts at 40°C; electrical rotation up to and including 360°. —*Electro-Mec Laboratory, Inc.,* 47-51 33*rd St., Long Island City* 1, *N.Y.*

For more information circle **241** on inquiry card.

MAGNETIC RECORDERS

New "FR 100 Series" of modular magnetic-recording components for application in data acquisition, stor-

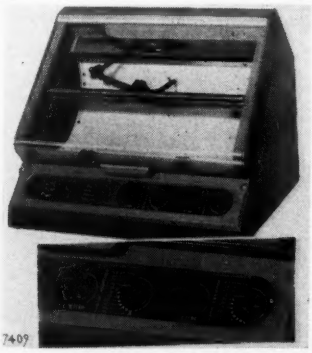


age, handling, processing, analysis, and simulation, comprises models with one to 14 tracks for recording and reproducing scientific data in dc to 100,000-cps frequency range. Maximum versatility for varying test requirements is provided by interchangeable plug-in amplifiers for direct, FM, and PWM types of recording and reproduction. Modular construction permits equipment expansion to fit user needs, allows incorporation of technological advances, and reduces maintenance to plug-in of spare modules.—*Instrumentation Div., Ampex Corp.,* 934 *Charter St., Redwood City, Calif.*

For more information circle **242** on inquiry card.

X-Y PLOTTERS

New "Models 200-A and 200-B" X-Y Plotters are said to offer "wider application possibilities for rapid graphic presentation of data, . . . greater accuracy, faster response, highest obtainable input impedance and greater flexibility than heretofore attained in instruments of this type." Prominent features in both new plot-



ters are a heavier 1-piece main casting for added strength and accuracy, and a new capillary pen containing an integral ink supply that provides easy flow and uniformity of line. As pen clamps on in a few seconds, spare pens can be easily interchanged to allow color comparison of two different runs.—*Librascope, Inc., Glendale* 1, *Calif.*

For more information circle **243** on inquiry card.

HIGH-SPEED PRINTER

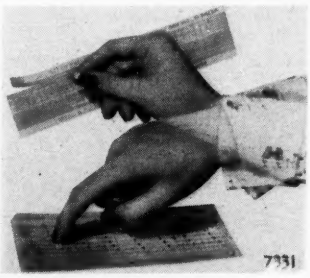
New special-purpose high-speed printer can turn out more than 2,500 lines a minute. A revolutionary electromagnetic process has been applied to printing results of numerical calculations of fast analog computers,

but technique can be used for facsimile reproductions of pictures, line drawings and lettered characters. Figures are printed in "ink" of magnetized iron particles pressed into wax-treated paper.—*General Electric Co., Schenectady* 5, *N. Y.*

For more information circle **244** on inquiry card.

KEY-PUNCH ERROR SEALS

New permanent self-sticking "Correction Seals" for plugging key-punch errors stick without moisten-

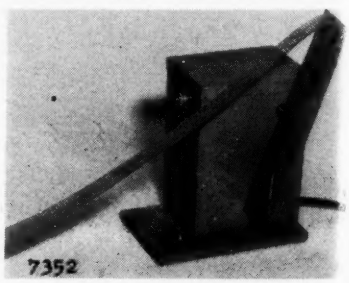


ing; are mounted 216 on a handy dispenser card allowing fast, one-at-a-time, one-motion application to correct key-punch errors.—*W. H. Brady Co.,* 727 *W. Glendale Ave., Milwaukee* 12, *Wis.*

For more information circle **245** on inquiry card.

TAPE FOLDER

New "Tape-File" electric folder for businesses that use large amounts of punched paper tape, operates from



Good coffee—the kind that attracts knowing truckers to their favorite roadside stops—depends on careful preparation, *and* maintenance at *just the right temperature until serving.* That's why manufacturers of restaurant coffee makers have consistently used Rochester Bimetal Dial Thermometers for years. They know RMC thermometers assure customer satisfaction by giving long, trouble-free, dependable service.

By the same token, RMC Industrial Thermometers have been first choice with equipment manufacturers and processors in the food, dairy, petroleum, chemical and petrochemical industries. They appreciate their rugged stainless steel construction, hermetically sealed fog-proof dial chambers, and the exclusive RMC external dial-reset feature. They, too, know from experience that they can always depend on the lifetime accuracy of RMC instruments.

Look to RMC for Full-Line Instrumentation—for manufacturers and users of processing equipment—and many consumer products.

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For more information circle **62** on inquiry card.

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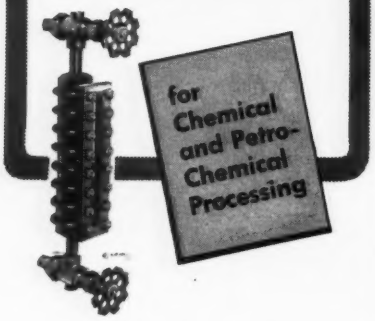

Working closely with the men in the field, Jerguson has developed a complete line of specialized gages, valves and other equipment to meet the specific needs of the chemical and petrochemical industries for the observation of liquids and levels. Available in stainless, monel, nickel, hastelloy and many other materials . . . with rubber, neoprene, lead, teflon, Kel-F, and other linings . . . in a variety of end, side or back connections.

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Pétrole Service, Paris, France

For more information circle **63** on inquiry card.

NEW INSTRUMENTS

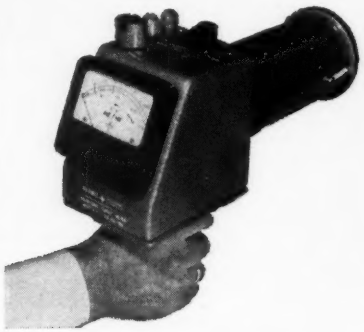
any 110-115 volt circuit. Tape can be stopped at any point without injury to tape or motor. Unit can be operated as a direct take-up from automatic equipment or accessory rolls. When a desired length has been wound, tape can be quickly removed from folding arm and is ready for storage without any other winding operation.—*Dresser Products, Inc., Providence* 5, *R.I.*

For more information circle **246** on inquiry card.

NUCLEONICS

SURVEY METER

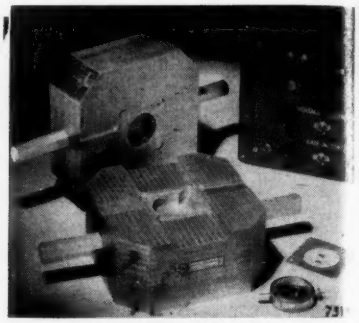
New single-scale "Model 414 Logarithmic Radiation Survey Meter" makes possible direct readings of x-ray, gamma and beta radiations over a full scale ranging from 3.0 to 3,000 milliroentgens per hour. It is claimed to eliminate errors in scale selection and obviates need for switching scales found in conventional linear-type survey meters.—*Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass.*



For more information circle **247** on inquiry card.

SAMPLE CHANGER

New "Model 6001" shielded manual sample changer minimizes time required for measurement of low-intensity radiation; provides $\frac{3}{16}$" aluminum plus 2" of lead in all directions. Counting can be carried out with only 1 tube, with the other connected either in anti-coincidence or entirely removed. Counting geometries of nearly 100% are provided through use of special counter tubes developed by maker's research staff.—*Anton Electronics Labs., Inc., 1226 Flushing Ave., Brooklyn 37, N. Y.*

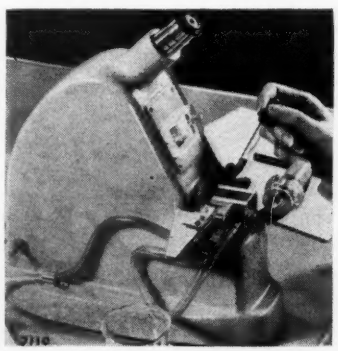


For more information circle **248** on inquiry card.

LABORATORY EQUIPMENT

REFRACTOMETER

New "Abbe-3L Refractometer" enables operator in one minute to load, light, and look into instrument to obtain refractive index of liquids, dissolved solids, and some opaque solids. Design innovations make instrument especially useful for production-line applications where it can be operated by non-technical workers.—*Bausch & Lomb Optical Co., Rochester, N. Y.*



For more information circle **249** on inquiry card.

GAS CHROMATOGRAPHY APPARATUS

New "Kromo-Tog Model K-2" is newest in maker's line of self-contained instruments for gas and vapor phase chromatography. Using principle of elution with either liquid partition or solid adsorbents, it provides complete and accurate breakdown of many different gas and liquid mix-

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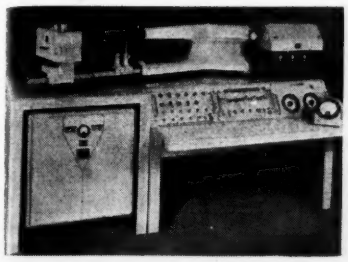
WRITE DIRECTLY TO THE HOTEL—Mention the Third International Automation Exposition

tures with a clear-cut resolution of all components. Analyses heretofore requiring complex equipment and taking hours to complete are reduced to everyday laboratory routine—*Burrell Corp.*, 2223 *Fifth Ave., Pittsburgh* 19, *Pa.*

For more information circle **250** on inquiry card.

DIRECT-READING SPECTROMETER

New "JAco-Hilger Direct Reading Medium Quartz Spectrometer" combines low price and high performance

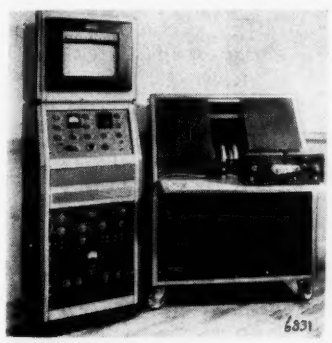


to bring to smaller producers of nonferrous metals analytical advantages formerly enjoyed only by larger firms. It will perform analyses for up to 11 constituents in two minutes or less with results indicated or recorded.—*Jarrell-Ash Co.*, 26 *Farwell St., Newtonville, Mass.*

For more information circle **251** on inquiry card.

CHEMICAL SPECTROMETER

New "Model S-1 Broad-line Chemical Spectrometer" permits rapid and non-destructive analysis of more than

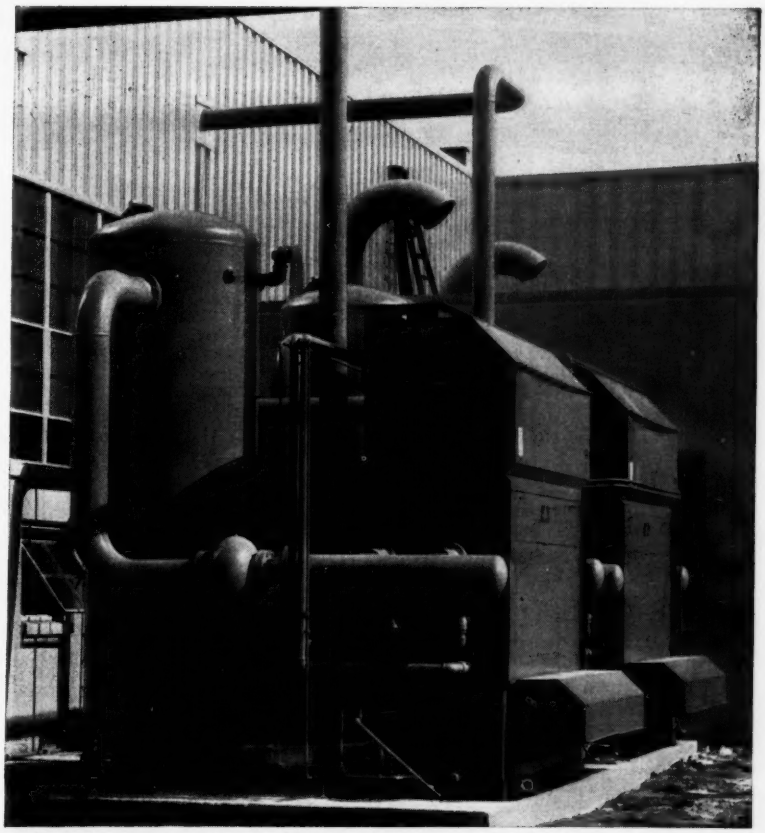


100 isotopes of 65 elements by use of techniques of nuclear magnetic resonance. Test samples of chemicals, complex chemical structures and combinations are rapidly and directly examined through RF techniques. No dehumidification or chemical destruction of test samples is necessary.—*Nuclear Magnetics Corp. Div.,—The Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle **252** on inquiry card.

CONSTANT-TEMPERATURE BATHS

New laboratory constant-temperature baths feature resistance thermometer and electronic bridge cir-



This Niagara Aero After Cooler also cools compressor jacket and intercooler water.

COMPRESSED AIR... Lower in Cost Dependably Drier and Cooler Trustworthy for Instrument Use

THE NIAGARA *AERO* AFTER COOLER offers a completely self-contained method replacing both shell-and-tube cooler and cooling tower. It is independent of a large supply of cooling water and consistently reduces compressed air temperatures to below ambient. Its drier air gives you a better operation and lower costs in the use of all air-operated automatic instruments, tools and machines, paint spraying, sand blasting and moisture-free air cleaning.

Direct saving in the cost of cooling water saves the price of the Niagara *Aero* After Cooler in less than two years. Water saving also means less expense for piping, pumping, water treatment and water disposal, or you get the use of water elsewhere in your plant where it may be badly needed.

Niagara *Aero* After Cooler assures all these benefits because it cools compressed air or gas below the temperature of the surrounding atmosphere; there can be no further condensation in your air lines. It condenses the moisture by passing the air thru a coil on the surface of which water is evaporated, transferring the heat to the atmosphere. It is installed outdoors, protected from freezing in winter, proven in service on the largest plant utility air systems.

Write for complete information; ask for Bulletin No. 130

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For more information circle **64** on inquiry card.

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Hold it with an H.J.J. Screw-holding Driver

Sizes to handle from #0 to #¼" screws

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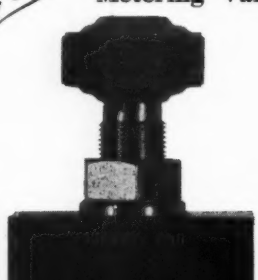
For more information circle **65** on inquiry card.

ROBBINS Leakproof Metering Valves



- Hi Vacuum to 6000 PSI.
- "O" Rings and Teflon or Nylon Seats are standard.
- Over-torquing cannot damage seat or needle as buffer plate and metering pin act as a forming die.
- Impossible to score needle or seat.
- Lifetime Valve—can be completely overhauled in a matter of minutes without disturbing plumbing or mounting.
- The most economical valve in the long run.

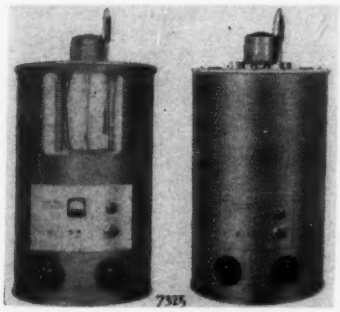
Write for further details.

ROBBINS AVIATION

1735 W. Florence Ave., Los Angeles 47, Calif.

For more information circle **66** on inquiry card.

NEW INSTRUMENTS



cuit which give a control accuracy of 0.001°C. Temperature ranges −10°C to 150°C, including mechanical refrigerated models. Full-view window models available.—*Bayley Instrument Co., Danville, Calif.*

For more information circle **253** on inquiry card.

TEFLON LAB GLAND

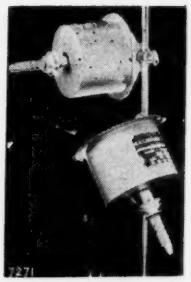
New "Asco Gland" features a unique Teflon construction that renders it chemically inert while vacuum-

tight; enables it to operate at temperatures as high as 200°C and prevents "freezing." Available in one size, 24/40 standard taper, with shafts of 6 mm or 10 mm; can be fitted with glass adapters for use in wider joints; can be sealed to a vacuum of 5×10^{-6} mm Hg, yet its use as a thermometer port still allows depth regulation of thermometer bulb.—*Arthur F. Smith Co., Rochester 3, N. Y.*

For more information circle **254** on inquiry card.

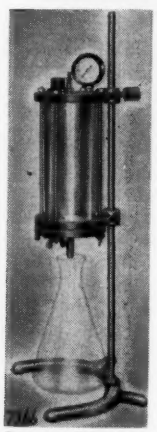
LOW-SPEED STIRRER

New "Slo-Speed" stirrer, developed especially for use in flash-point tests, can be adapted to any lab procedure requiring stirring at a low constant speed: 78 rpm on direct drive, other speeds through use of pulleys. Motor draws 15 watts, has 0.9-lb-in starting torque.—*Precision Scientific Co., 3737 West Cortland St., Chicago 47, Ill.*



For more information circle **255** on inquiry card.

CYLINDER-TYPE FILTERS

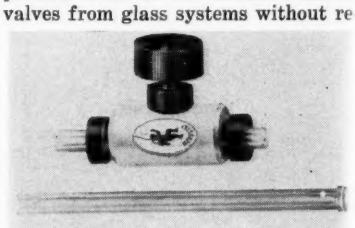


New laboratory cylinder-type filters are available in stainless steel, hard rubber, plastic, or nickel-plated brass. A Pyrex glass cylinder permits full view of product during filtering process. Pressure gage (0-60 psi) is standard equipment. Four new models with areas from 3.34 to 21 sq in.—*Erte Engineering Corp., Kingston, N.Y.*

For more information circle **256** on inquiry card.

GLASS-SYSTEM NEEDLE VALVE

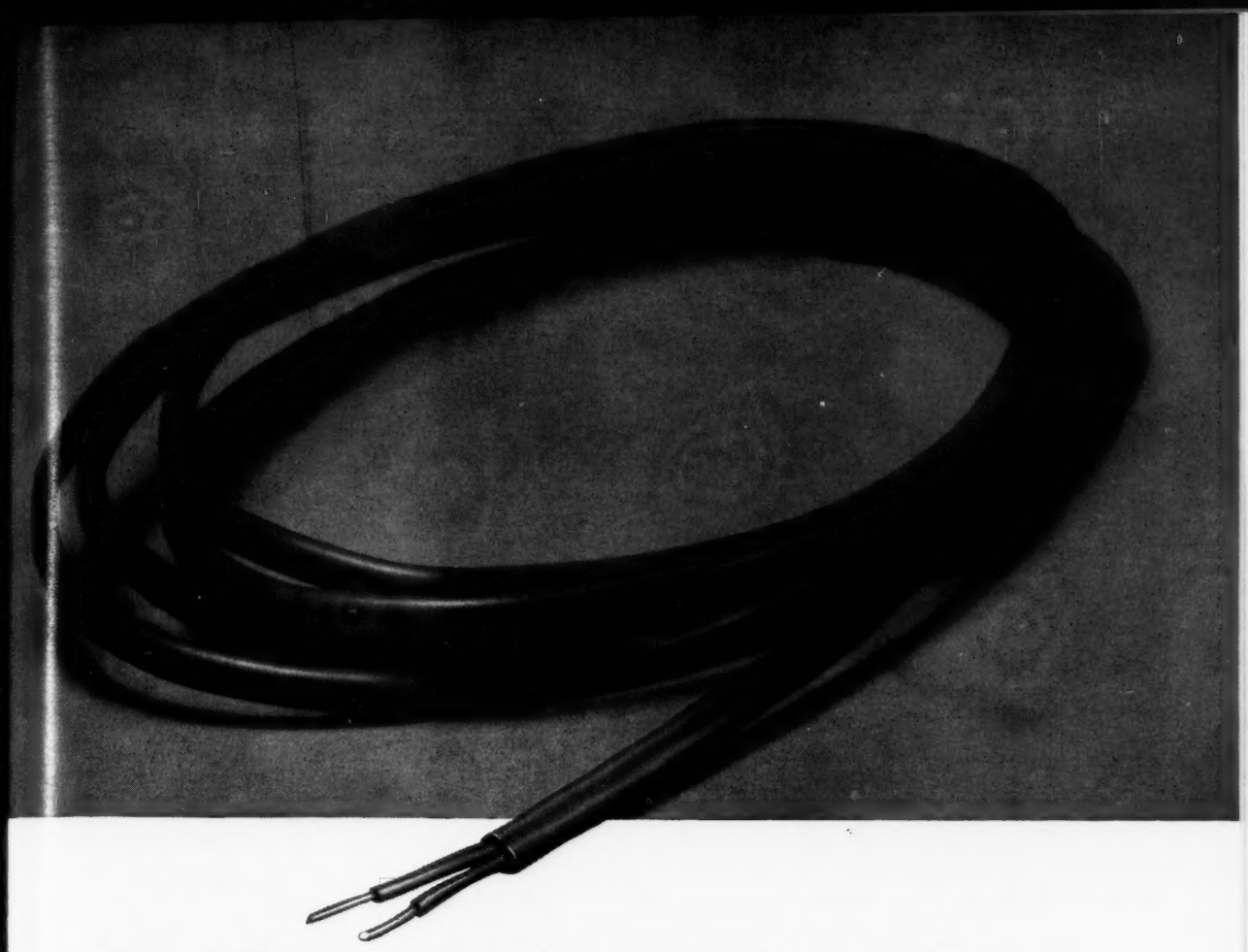
New Teflon and glass needle valve perimts removal of corrosive needle valves from glass systems without re-



SPECTROPHOTOFLUOROMETER

New "Aminco-Bowman" spectrophotofluorometer is a new analytical instrument, combining advantages of spectrophotometry and sensitivity of fluorescence measurements, for identification of compounds in solution throughout visible and UV regions.—*American Instrument Co., Silver Spring, Md.*

For more information circle **257** on inquiry card.



New thermocouple extension wire flame-proof, weather-proof

. . . available through your HSM

HONEYWELL SUPPLIES MAN

HERE'S a thermocouple extension wire with superior insulation. Each of the two solid conductors is insulated with .015" polyvinyl, and the pair is further protected by an outer .02" polyvinyl jacket. It's the ideal wire for even the toughest service. What makes it better than ever is a *new kind* of polyvinyl insulation that gives these qualities:

Won't become tacky or stick to conduit walls, even when overheated.

Won't support flame. Fire merely chars the coating. You can rewire without replacing the conduit.

Abrasion-resistant. Jacket won't break or fray in roughest service.

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Weather-proof . . . double vinyl insulation gives extra protection.

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Ask your local HSM (Honeywell Supplies Man) to tell you about this new wire . . . and to discuss how the HSM Plan can bring new convenience and economy to all your pyrometer supplies purchases. Call him today, at your local Honeywell office . . . as near as your phone.

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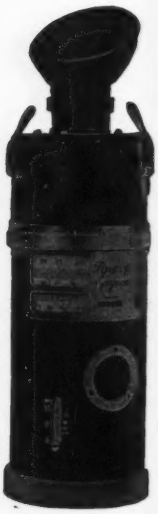
First in Controls

For more information circle **67** on inquiry card.



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Read Temperatures directly!

—the only self-contained, direct-reading light-weight and dependable unit for quick and accurate high-temperature measurements. Determines temperatures of minute spots, fast-moving objects, or of smallest streams. Even measures accurately the true spout and pouring temperatures of molten iron, steel, monel, etc. in the open. Ranges from 1400-7500° F. or in equivalent Centigrade calibration. Write for free Catalog No. 85.

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PRESSURE TRANSDUCER

Diameter: 2¼"

Weight: 12 oz.

An extremely sensitive variable inductance instrument for measurement of steady and transient pressure in full scale ranges as low as ± 4 inches of water. Permissible pressure overload in either direction up to maximum line pressure, 100 psi, for difficult flow-metering applications. A light diaphragm sensing element free from external mechanical linkage results in high natural frequency for dynamic measurements.

MODEL DP-7 SPECIFICATIONS:

Pressure Ranges:.....± 0.15 to ± 15 psid
Maximum Line Pressure:.....100 psi
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For more information circle **69** on inquiry card.

NEW INSTRUMENTS

sorting to stopcocks. It replaces stopcocks in any laboratory apparatus. Teflon rings enable the valve to be instantly interchanged with existing glass parts.—*The Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y.*

For more information circle **258** on inquiry card.

SPECTROPHOTOMETER ACCESSORIES

New accessories for "DK Recording Spectrophotometers" enable chemist to use recording spectrochemistry for more of his lab analysis and research: Flame Attachment adapts "DK-1 and DK-2" for rapid qualitative analysis of metals in a sample. Linear wavelength recording, standard on "DK-1," can now be accomplished with a "DK-2" by use of Linear Wavelength Attachment. Studies below 0.2 micron and above 3 microns are facilitated by a Purging Kit. New Germanium Filter is useful above 3 microns to reduce stray light. Variable Cell has path length that can be adjusted from 0.25 mm to 10 mm. Constant Temperature Holder for thermostatting cell and sample. Continuous Flow Cell for analysis of a flowing sample. Dual Source Unit for rapid interchange of hydrogen and tungsten lamps. KBr Die and Die Holder for special infrared studies. Repetitive Scan Attachment for "DK-2" and Time Drive for studies of reaction rates.—*Scientific Instruments Div., Beckman Instruments, Inc., Fullerton, Calif.*

For more information circle **259** on inquiry card.

ULTRAVIOLET SOURCE

New "Blak-Ray Model BLF-6," for better observation of low-grade fluorescence, particularly in critical areas

7208

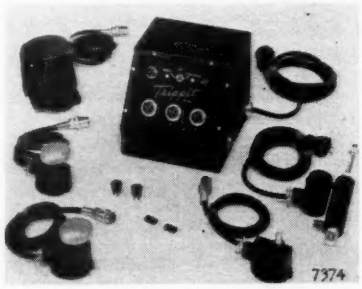
of pale blue, light green and red, utilizes a tubular filter to cut down on visible light emission. With its peak emission at 3660 AU, it is especially valuable for sanitation inspection, criminology, chromatography, oil analysis, medical diagnosis and wherever subtle shadings must be observed.—*Black Light Corp. of America, San Gabriel, Calif.*

For more information circle **260** on inquiry card.

SHOP EQUIPMENT and SUPPLIES

POWER PRESS CONTROLLER

New "Trippit" electric combination master control for power presses, shears and brakes replaces much



7374

of operator's burden with automatic control, permits him to perform his task with less fatigue and greater safety; increases production, eliminates rejects and lessens down-time from jamming or die damage.—*General Automation Corp., 65 South Broadway, Yonkers, N.Y.*

For more information circle **261** on inquiry card.

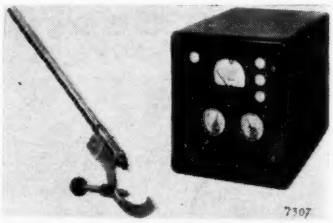
PACKAGING MATERIAL

New "Fibre Form" molded pulp can double speed of packaging components or assemblies; is molded in many sizes, shapes and weights to give greatest protection at lowest cost.—*Arvey Corp., Fibre Forming Div., Olean, N. Y.*

For more information circle **262** on inquiry card.

GRINDER CONTROLLER

New "Type 150 Microtrol" for automatic control of plunge grinders gages workpiece diameter continuously during grinding, and uses gaging information for automatic control of final size. In addition, part size is continuously presented on a set of direct-reading indicators, and indicator lights signal arrival at the various size limits, including final size. Special units are available for external centerless grinders, etc.—*Airborne Instruments Lab., Inc., 160 Old Country Rd., Mineola, N. Y.*



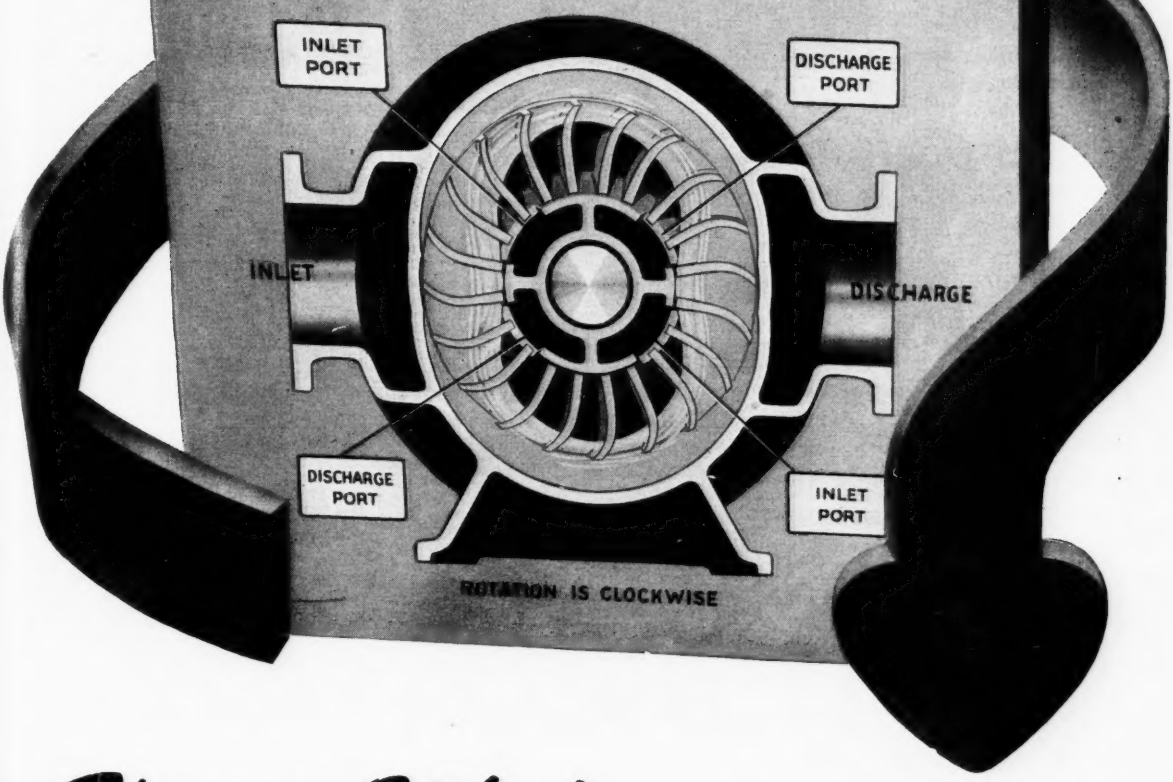
7307

For more information circle **263** on inquiry card.

HYDRAULIC PRESS CONTROL

New "E364 Robotron Control" is a completely packaged unit whose installation is simple; features operating pushbuttons on case, inclusion of solenoid air valve within case, flexibility of cycle set-up in a few seconds, all relays enclosed and plug-in type for easy checking or servicing,

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
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Non-pulsating pressure.
Original performance constant over a long pump life.
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For more information circle **70** on inquiry card.

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Parabolic, Spherical, Ellipsoidal and Plane Mirrors

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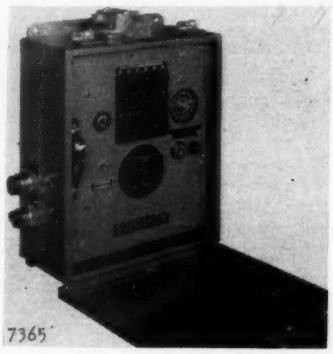
For more information circle **71** on inquiry card.

NEW INSTRUMENTS

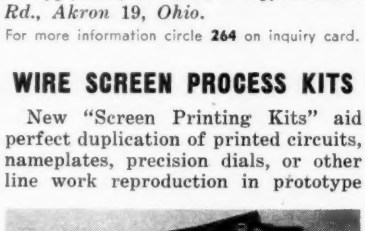


and timing motor itself plug-in for readily changing control from one range to another.—*Emmett Machine & Mfg., Inc.*, 445 *E. Turkeyfoot Lake Rd., Akron* 19, *Ohio.*

For more information circle **264** on inquiry card.

WIRE SCREEN PROCESS KITS

New "Screen Printing Kits" aid perfect duplication of printed circuits, nameplates, precision dials, or other line work reproduction in prototype

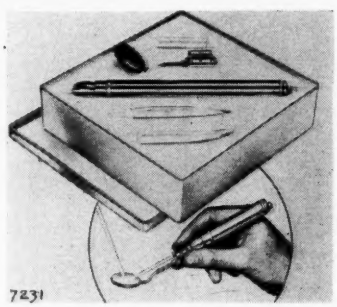


or quantity amounts. Each kit contains all necessary materials and information for doing in a professional manner marking work previously "sent out" by most companies. "Kit # 5006P" (shown in photo) can be obtained from jobbers. A more extensive "Industrial-Laboratory Kit # 5005P" includes complete materials and instructions for investigation of etched-wire printed circuitry.—*Techniques*, 178-84 *Central Ave., Hackensack, N. J.*

For more information circle **265** on inquiry card.

INSTRUMENT ILLUMINATOR

New "Conduct-A-Lite" utilizes light conduction through 5/16" lengths of Lucite, illuminates dark areas in in-



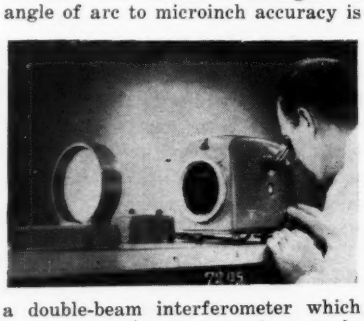
accessible places, around corners, etc.; is useful for inspection, assembly, adjustment and repairs; needs no power line: uses standard pen light batteries. Rod length to 24". Various optional accessories.—*Foster Supply Co.*, 6122 *Milwaukee Ave., Chicago, Ill.*

For more information circle **266** on inquiry card.

DIMENSIONAL GAGING and INSPECTION

ALIGNMENT INTERFEROMETER

New experimental alignment interferometer to measure changes in angle of arc to microinch accuracy is

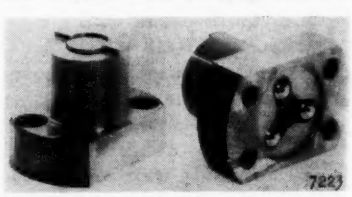


a double-beam interferometer which detects small changes in angle through a total range of 30 seconds of arc. Its mirror can be located as much as 14 feet away. It can be rested on its base, side, or end to measure alignment of jigs, fixtures, or flat-bed surfaces.—*Bausch & Lomb Optical Co.*, 635 *St. Paul Street, Rochester, N. Y.*

For more information circle **267** on inquiry card.

FLUSH PIN AMPLIFIER GAGE

New amplifying modification of flush pin gage has same characteristics as plain flush pin gage but with

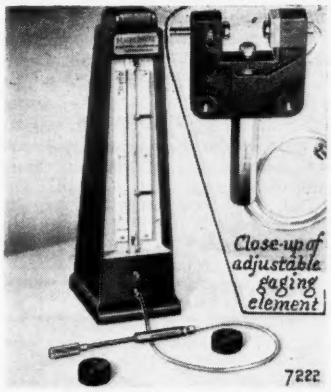


a 5× amplification, hence is practical even down to a manufacturing tolerance of 0.001". Advantages include cost-cutting, because setting master, mounting bracket and protective hood are superfluous, and because of absence of gage maintenance. Amplifying mechanism comprises three high-precision hard-steel balls, held 120° apart about cone-shaped end of slidingly-disposed pin.—*A. M. DeLeo & Associates, Inc.*, 18220 *W. Seven Mile Road, Detroit* 19, *Mich.*

For more information circle **268** on inquiry card.

COLUMN-TYPE AIR GAGES

New models of "Dearbornaire" are designed to provide maintenance-free operation as well as greater versatil-

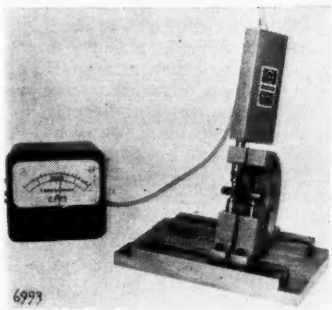


ity, ease of operation, and longer gaging-element life. Among major design features: (1) higher rated pressure system combined with built-in circuit restrictions to assures a constant air pressure sufficient to keep instrument self-purged; (2) exclusive new glass tube with "characterized" internal taper which assures perfect linearity. ★ Complete line of air gaging elements (interchangeable on all three standard amplifications): spindles, rings, snaps, etc. with steel, chromium plates or carbide gaging surfaces.—*Air Gage Div., Dearborn Gage Co.*, 22038 *Beech St., Dearborn, Mich.*

For more information circle **269** on inquiry card.

ELECTRONIC MICROMETER

New "Minitron" permits unskilled help to check up to 3,500 pieces an hour at tolerances less than 0.0001";

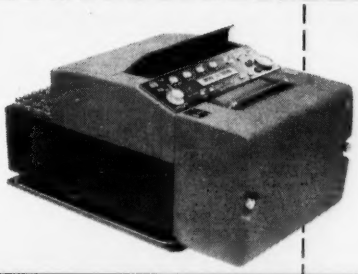


features two sets of adjustable anvils for accepting a production run for quick checking without "feel." This permits gage stand to be quickly preset and locked to conform to a master. Adjustment permits shop foreman or chief inspector to establish any magnification desired from 10,000/1 to 1,000/1.—*EAM Div., Industrial Gauges Corp., Englewood, N. J.*

For more information circle **270** on inquiry card.

ELECTRONIC "GO AND NO-GO" CONTROL SYSTEM

New "Myke-A-Trol" is designed for use with measuring elements built into gage heads, for gaging and sort-



any way you look at it...

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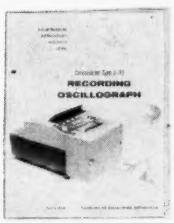
At the top and right are the standard 5-119; at the lower left is the 5-119R, specially engineered for vertical rackmounting and tilting forward for easy loading and adjustment. These twin instruments can be used almost anywhere there is data to be recorded . . . laboratory, test stand, aircraft, instrumentation trailer. The capacity (up to 50 channels), the range of speeds, the record width, and the unusual group of built-in safeguards against data loss make the 5-119 ideal for over 90% of all static-dynamic tests, regardless of their complexity. With the 5-119, you're *sure* to get the data . . . *anywhere!* Both models are effectively shockmounted, hold 450 feet of 12″ paper, record at speeds from 0.1″ to 100″ per second, with *instant* 10:1 speed change through simple switch control. A-C or D-C models, 36 or 50 channels. Accommodates galvanometers linear from 0 to 3000 cps. Complete details and specifications in Bulletin CEC 1536B-X7.



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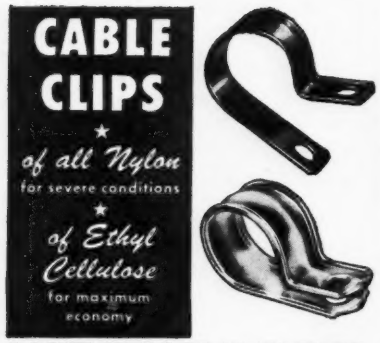
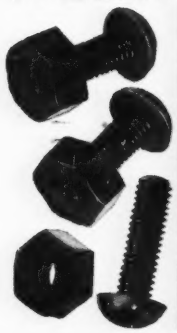
For more information circle **72** on inquiry card.



WECKESSER



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For more information circle **73** on inquiry card.

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HYDROSTATIC GAUGES
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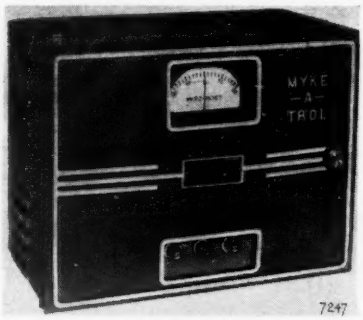
For more information circle **74** on inquiry card.

NEW INSTRUMENTS



7247

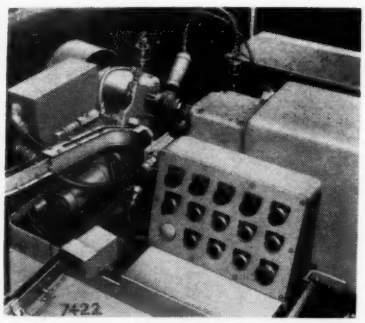
ing, fatigue testing, inspection, and thickness control, etc. Overall accuracy 2% using standard pickups. Displacement ranges of plus and minus 0.1" to plus and minus 100 microinches. Any phenomenon, such as pressure, weight, etc., can be measured in terms of dimensional change, and controlled accordingly. Two power relays can be adjusted to operate at any desired control point, on plus or minus tolerances, two successive plus tolerances, or two successive minus tolerances.—*Industrial Electronics, Inc.*, 8060 *Wheeler St., Detroit* 10, *Mich.*

For more information circle **271** on inquiry card.

MECHANICAL TESTING

AUTOMATIC GEAR TESTER

New fully automatic "Red Ring Model GSR Gear Speeder" includes an "electronic ear" that inspects and

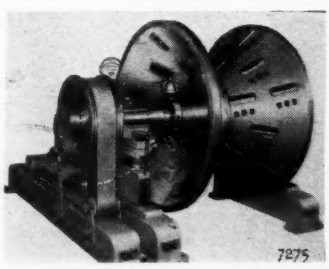

7422

rejects gears on basis of operating sound level. Sound discriminator unit can be adjusted at any time to range of audible noise frequency and intensity desired for rejection.—*National Broach & Machine Co.*, 5600 *St. Jean Ave., Detroit* 13, *Mich.*

For more information circle **272** on inquiry card.

BALANCING MACHINE

New "Mogul" balancing machine is said to reduce complex balancing operations to "the absolute in mechani-

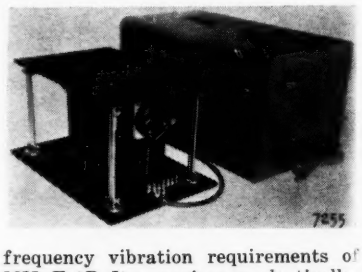

7275

cal simplicity." Pedestal type design permits units to be placed together or separated according to length of piece to be balanced: shortest rotors or longest paper-mill roll. Drive unit can be positioned at either end or in center. To locate and measure unbalance (small as well as large) "Mogul" employs a true seismic free-in-space unbalance indicator providing over 4" of free amplitude travel. Operator can correct large amounts of unbalance at low, safe speeds.—*Raydyne Corp.*, 920 *West Laurel St., Springfield, Ill.*

For more information circle **273** on inquiry card.

VIBRATION GENERATOR

New "Model AF" low-cost 10-60-cps adjustable-frequency vibration machine meets fatigue test and low-

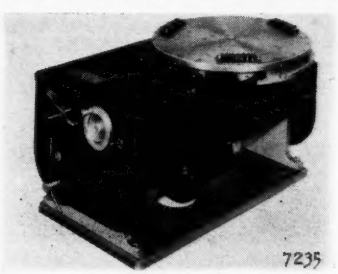

7255

frequency vibration requirements of MIL-E-1B. It comprises an elastically-mounted platform, pickoff, forcing transducer, and power amplifier. It features unique selfperpetuating resonant drive principle and provides long and uniform vibration life because all motion is by means of flexing steel members: no rotating shafts, bearings, or sliding members. Maximum load 70 lb, maximum amplitude 0.1". —*Lance Products, P. O. Box* 251, *Forest Hills* 75, *N. Y.*

For more information circle **274** on inquiry card.

RATE-OF-TURN TABLE

New small low-cost rate-of-turn table, for use in calibrating and evaluating rate gyros, is suited for flight-


7235

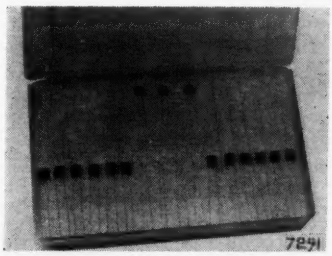
line testing at aircraft, as well as production-line use. Accuracy of setting and repeatability within 1%; angular velocity is constant to about 0.25% including cumulative drift, wow and flutter errors. Vibration accelerations do not exceed 0.015 *G* at frequencies up to 500 cps. Two ranges available: "Model G347" 1° to 600° per second; "Model S347" 0.1° to 60° per second.—*Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.*

For more information circle **275** on inquiry card.

ELECTRICAL TESTING

THERMISTOR TEST KITS

New thermistor test kits enable design engineers to economically investigate and evaluate semiconductor po-

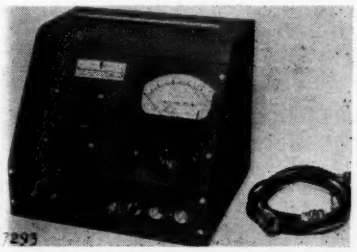


tentialities; are available in three sizes; wide range of resistances, temperature coefficients and sizes. Mountings and styles incorporated in sets include maker's wafer thermistors in addition to bead, bead-in-probe and bead-in-can elements.—*Thermistor Corp. of America, Metuchen, N. J.*

For more information circle **276** on inquiry card.

RANDOM PULSE GENERATOR

New "Model 422" completely transistorized portable random pulse generator delivers random pulses at a



controlled rate from 10 to 1000 pulses per second; operates for over 100 hours from 4 standard 1½-volt flashlight batteries, at 5 mv to 5 v output, from a 100-ohm impedance source.—*Universal Atomics Corp., 19 E. 48th St., New York 17, N. Y.*

For more information circle **277** on inquiry card.

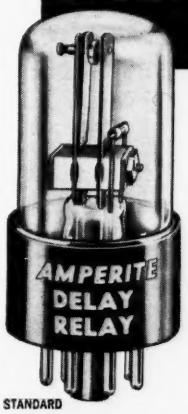
DUAL TRACE GENERATOR

New "Model 600A" converts any standard oscilloscope to a dual-input unit by chopper sampling two inputs

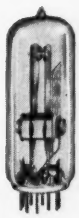
True Hermetic Sealing assures Maximum Stability

in AMPERITE RELAYS and REGULATORS

Simplest • Most Compact • Most Economical



STANDARD



MINIATURE

Thermostatic DELAY RELAYS

2 to 180 Seconds

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes.
- *SPST only* — normally open or normally closed.

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from −55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived, and — inexpensive!*

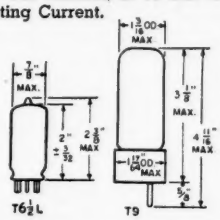
TYPES: Standard Radio Octal, and 9-Pin Miniature

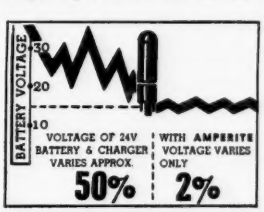
PROBLEM? Send for Bulletin No. TR-81

Also — **Amperite Differential Relays:** Used for *automatic overload, under-voltage or under-current protection.*

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp.) ... For currents of 60 ma. to 5 amps. Operate on A.C., D.C., Pulsating Current.





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Individual inspection and double-checking assures top quality of **Amperite** products.

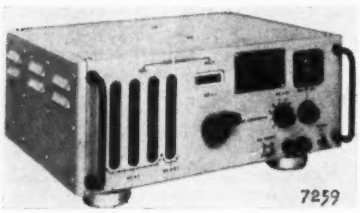
For more information circle **75** on inquiry card.

at a 60-cps rate; both signals then appear simultaneously on scope, and vertical separation between them is adjustable.—*Electro-Pulse Inc.*, 11861 *Teale St., Culver City, Calif.*

For more information circle **278** on inquiry card.

FREQUENCY SYNTHESIZERS

New "Series 182 Crystal Frequency Synthesizers," each capable of producing from 2000 to 20,000 discrete frequencies with an accuracy of 0.0001%



and zero-error resetability, feature substantial immunity to environmental conditions and suppression of spurious signals (except harmonics of output) to −80 db. Three models: "182-A," HF, 18 to 36 Mc; "182-B," VHF, 72 to 144 Mc; "182-C," UHF, 215 to 410 Mc. Additional models soon available, 2 to 32 Mc and 72 to 410 Mc as well as modifications for use as complete AM or FM transmitters. Unskilled personnel can operate synthesizers without training or prior experience.—*Manson Laboratories*, 207 *Greenwich Ave., Stamford, Conn.*

For more information circle **279** on inquiry card.

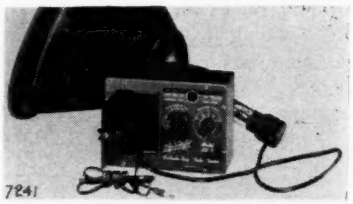
QUADRUPLE PULSE GENERATOR

New "Model 340" generates four square pulses of one millimicrosecond rise time. Widths vary from 0.001 to 0.1 usec selectable on front panel. Four separate pulse outputs can be independently varied in amplitude in 1-db step over range of 0.006 to 100 v into low-impedance cables. Outputs can be matched to any impedance from 50 to 200 ohms, and can be independently delayed if desired.—*Electrical & Physical Instrument Corp.*, 25 *W. 43rd St., New York* 36, *N. Y.*

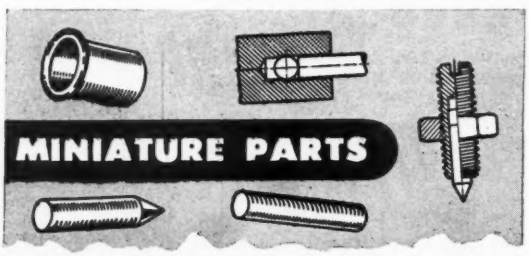
For more information circle **280** on inquiry card.

TV PICTURE TUBE TESTER

New "Model CR5 Videochek," specifically designed for use by TV servicemen and dealers, has been field tested and found to be better than 98% accurate in anlyzing typical TV picture tube defects other than screen or face plate defects which are readily apparent in operating the tube with a raster.—*The Hickok Electrical Instrument Co.*, 10519 *Dupont Ave., Cleveland* 8, *Ohio.*



For more information circle **281** on inquiry card.



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Instrument Pivots
- As separate items or mounted in components—special steel, heat treated for maximum hardness, polished, metallographic finish. To specifications up to 3/8" diameter.

Shafts and Staffs
- Burrless, plain or alloy steel, heat treated to specifications. Metallographic finish.
- Tubular Products up to 3/8" Diameter, Cut, Flared, Swaged, Formed and Burr-Free. Alloy or Silver Plated.
- Screw-Machine Products up to 3/4" Diameter.

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- A Multitude of Services are Available for Customers' Parts at Any Stage of Manufacture. These Include: Controlled-Atmosphere Heat-Treating, Centerless Grinding, Surface Grinding, Special Facilities for Ceramic Rods and Shapes, Knurling, Thread-Rolling to close tolerances, Swaging, Drilling, Milling, Burr Removing, Metallographic Polishing, Barrel-Plating in Alloy or Silver, light Punch-Press Work.

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- "Welton" noncorrosive paste solder for hairsprings or similar soldering.
- "Wentanoil" treated bottonwood pith for lubricating instrument pivots.

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Accurately RECORD calorific values of gases from 80 B.t.u.'s and up

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- Require little maintenance
- Simple in design
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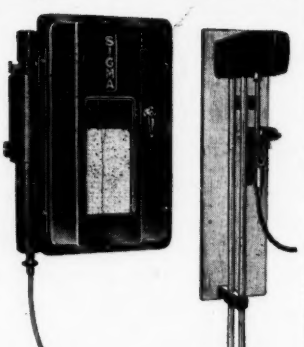
- Free from continuously moving parts—except for chart drive
- Low in cost



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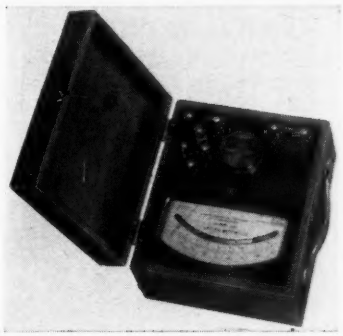
NATIONAL REPRESENTATIVES FOR SIGMA INSTRUMENT CO., ENGLAND

For more information circle **77** on inquiry card.

ELECTRICAL and ELECTRONIC INSTRUMENTS

ASTATIC INSTRUMENTS

New line of astatic wattmeters, voltmeters and milliameters should interest users in aircraft electronics

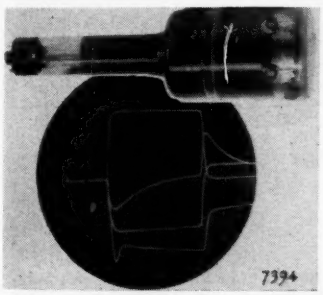


and servomechanisms, where power supplies operate at 400 to 1000 cps and where previous 60-cps instrumentation is inadequate. They are electrodynamometer type instruments with an entirely new coil system. Improved frequency response stems from high coupling coefficient between moving coil and fixed coils, and through elimination of eddy current effects usually present in magnetic shielding and other metal parts.—*Rawson Electrical Instrument Co., 110 Potter St., Cambridge 42, Mass.*

For more information circle **282** on inquiry card.

TRACE-RETAINING CRT

New "Memotron" 5" direct-display storage tube can capture and retain visual displays of transients without



resorting to photography. Utilizing a special storage target just behind viewing screen, it retains single tracings or successive writings at high brightness until they are intentionally erased. Photography need be used only when permanent records are required for files.—*Hughes Products, Los Angeles 45, Calif.*

For more information cricle **283** on inquiry card.

RF Q METER

New "Advance Model T-1 RF *Q* Meter" (English-made) features a unique overload-proof VTVM indi-

Engineers...

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Products Division has outstanding openings in its newly-established

INDUSTRIAL SYSTEMS & CONTROLS SUB-DIVISION

With the broad experience gained from its military products, Hughes has established an Industrial Systems and Controls activity to design, manufacture, and sell commercial electronic systems. At Hughes, the West's leading center for advanced electronics, you will be concerned with industrial controls using digital techniques and transistorized circuits.

These are key positions requiring executive and managerial ability and must be filled! The long range possibilities for advancement and progression in these new positions is unlimited. The activity, already quite extensive, is planned to grow to several times its present size within a few years. Openings exist for:

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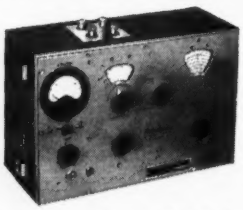
NEW INSTRUMENTS

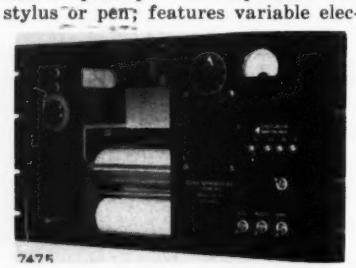


cator, will measure with laboratory precision *Q*, power factor, inductance and capacitance at RF frequencies.—*Fisher Radio Sales Co., Inc.* 21-21 *Forty-fourth Drive, Long Island City* 1, *N.Y.*

For more information circle **284** on inquiry card.

FREQUENCY-RESPONSE RECORDER

New "Model SL-4 Sliding-Coil Recorder" utilizes a unique electrodynamic principle for operation of stylus or pen; features variable electronically-controlled writing speed and electronically-controlled damping of pen movement; records on a 4" wide chart at chart speeds of 4½, 9 and 18 ipm selectable by a push-button arrangement. Scale function depends on "input potentiometer" which can be furnished as decibel, linear, square root, or phon. Link units are available for widely-used beat-frequency oscillators and wave analyzers. Special link units and correspondingly-calibrated charts to order.—*Sound Apparatus Co., Stirling, N. J.*



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For more information circle **285** on inquiry card.

RADIOFREQUENCY VOLTMETER

New "Model 91-A R-F Voltmeter" provides measurements down to 0.001 v from 0.2 to 400 Mc; comes with two probes, a high-impedance unit and a 50-ohm type with low vswr. Full-wave crystal diode detector circuit gives rms response in square-law region up to 0.1 v, with high readings gradually changing from rms to peak response calibrated in rms for sine waves to 3 v maximum. With 50-ohm probe, instrument can measure down to 0.02 microwatts.—*Boonton Electronics Corp, Morris Plains, N. J.*

7330

For more information circle **286** on inquiry card.

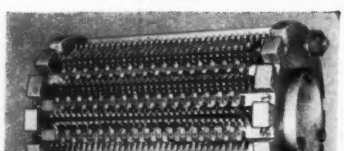
DIGITAL OHMMETER

New "Model D 050" digital ohmmeter automatically measures and digitally displays resistance measurements to 5 digits; has a range of 0.1 ohm to 10 megohms, and is accurate up to 0.01% ± 1 digit, depending upon range. Average reading time is one second. Range switching is automatic. It can be used with maker's "Input Scanner IS100" and machine print-out to sequentially scan and record 100 resistance values.—*Electro Instruments, Inc.*, 3794 *Rosecrans St., San Diego* 10, *Calif.*

7359

For more information circle **287** on inquiry card.

Magnetic Drum



Retains 250,000 Bits

Each of the 256 heads of the Wharf Mark III Storage Unit has individual adjustment and can be removed and replaced independently. The eight columns of the unit have a capacity of 8193 words of 32 binary digits each, a total of over 250,000 bits.

Writing current required is 0.8amp at the head, or 15 to 20ma at input of the T3 transformer. Normal pulses are one to two mic/sec. wide. Driven directly by a 1/6 hp induction motor, the unit has a maximum speed of 6000rpm, with a digit rate of 1000kc.

Manufactured by

Wharf Engineering Laboratories *of* **England**

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58 Charles Street Cambridge 41, Mass.

For more information circle **78** on inquiry card.

IMPERIAL *Poly-Flo* TUBE FITTINGS and Polyethylene Tubing

Offer Huge Savings in Time and Simplify Installation

Fittings and Tubing furnished in ¼", 5/16" and ⅜" O.D. sizes.

Recommended for working pressures to 125 psi.—¼" O.D.; 100 psi. — ⅜" O.D.

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Poly-Flo Tube Fittings, used with polyethylene or other plastic tubing, offer tremendous savings in time and labor through ease of assembly and installation. Ideal for instrumentation, laboratory equipment, food and beverage plants and many other applications.

Fittings need only be finger tightened. A wrench is never necessary.

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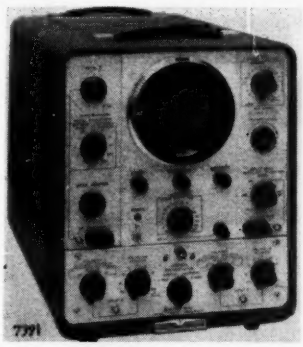
IMPERIAL *Industry's Most Complete Line of Tube Fittings and Tubing Tools*

For more information circle **79** on inquiry card.

10-MC OSCILLOSCOPE

New "Model 150A" high-frequency CRO features maximum versatility and convenience with extreme elec-



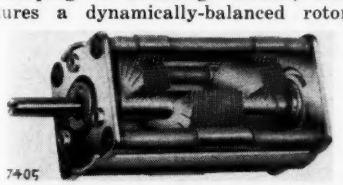
trical and mechanical dependability. Dc to 500 kc horizontal amplifier provides sweep magnifications of 1, 5, 10, 50, and 100, which, together with special horizontal position control, offer a means of fine adjustment and examination of any 10-cm portion of magnified range. Full sweep range is 0.02 usec/cm to 15 sec/cm.—*Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.*

For more information circle **288** on inquiry card.

ELECTR-INSTRUMENT ACCESSORIES

RAPIDLY-VARIABLE CAPACITOR

New "Model #1741," applicable to sweeping or scanning circuits, features a dynamically-balanced rotor

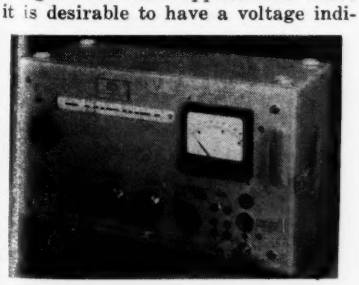


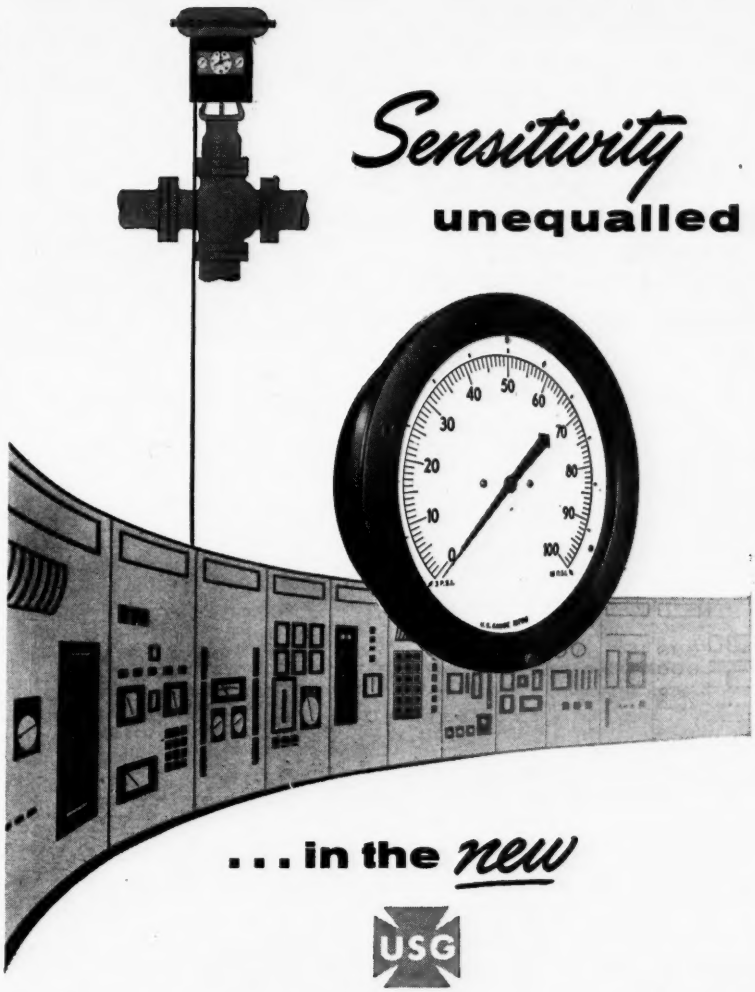
which can be operated at speeds up to 1800 rpm with no vibrational problem. Capacitance variation is SLO with maximum of 128 mmf. and minimum of 7.5 mmf.—*Johansen Mfg. Corp., Boonton, N. J.*

For more information circle **289** on inquiry card.

TUNABLE DETECTOR AMPLIFIER

New "Type FT-UBM" highly-sensitive tunable detector amplifier is designed for those applications where it is desirable to have a voltage indi-





Diaphragm Receiver Gauges

The new USG Receiver Gauges provide a radical departure in design and performance from any other Receiver Gauge on the market.

The key to the design is a stack of nested diaphragms . . . made of Ni-Span "C", a special high nickel alloy with a minimum thermal shift, even under wide variations in ambient temperature. These capsules are arranged in stacks occupying minimum space yet providing a sturdy element with extended travel for precise pointer response.

Standard USG Receiver Gauges provide a sensitivity of 1/10 of 1%, accuracy of ± ¼ of 1% . . . both based on full scale readings, and are available in a choice of 4½", 6" or 8½" dials.

Write today for details on the USG Receiver Gauge, one of the line of USG creatively engineered, process control instruments. This line includes pressure and temperature pilots, pneumatic transmitters, recorders and controllers.

UNITED STATES GAUGE
USG
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Sellersville, Pa.
Home of the **SUPERGAUGE**

For more information circle **80** on inquiry card.

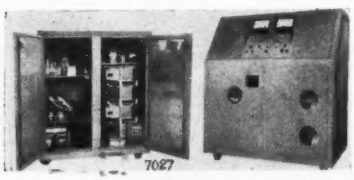
cator or amplifier with either a flat wideband response, or a pass band of adjustable bandwidth; is tunable from 45 cps to 400 kc.—*Federal Telephone & Radio Co.*, 100 *Kingsland Rd., Clifton, N.J.*

For more information circle **290** on inquiry card.

POWER SUPPLIES

CONSTANT-CURRENT SUPPLIES

Four new closely-regulated constant-current magnet supplies are for use with magnetrons, travelling-wave



tubes, mass spectrometers, cyclotrons, etc.; provide long-term current stability better than 100 parts per million, independent or supply line fluctuation or magnet heating; voltage ripple less than 0.1% peak-to-peak. Illustrated is "Model CS-3866" rated at 0-8 amp., 0-2500 v.—*N J E Corp.*, 345 *Carnegie Ave., Kenilworth, N. J.*

For more information circle **291** on inquiry card.

300 VDC SUPPLY

New "Model 214" regulated power supply features a 6.3 vdc filament supply for applications where low-noise filament circuits are required. A conventional 6.3 vac filament supply is also provided. Additional features include provisions for remote control of unit. Main B+ voltage output, +300 vdc at 20 to 200 ma, is regulated within 0.04%. Ripple is less than 0.003% and effective output impedance 2 ohms or less from 40 to 4000 cps.—*Link Aviation, Inc., Binghamton, N. Y.*

For more informaiton circle **292** on inquiry card.

REGULATED HV SUPPLY

New improved version of "N-401" is an ultra-stable-regulated high-voltage power supply for advanced areas of research and development. It is said to provide "a high degree of stability heretofore available only with batteries." Stability is limited only by VR tubes (which are the new ultra-stable 85A2 operated under constant current). When switched by coarse control, voltage can be reset to better than 10 ppm at any time. "N-401" provides continuously variable voltages from 500 to 1800 positive, at load currents up to 5 ma.—*Hamner Electronics Co., Inc., P. O. Box 531, Princeton, N. J.*

For more information circle **293** on inquiry card.

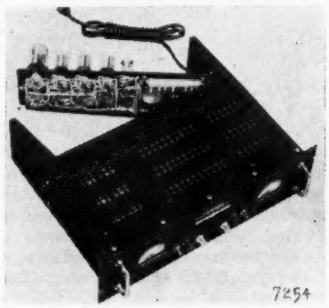
MAG-AMP-REG SUPPLY

New "Model MR2432-100XA" magnetic-amplifier-regulated dc power supply has a voltage output of 24-32 at 100 amp; is tubeless; contains no moving parts except a cooling fan and is said to be unique in that it has a 3.2-kw output from a cabinet only 26½" long x 17" high.—*Perkin Engineering Corp.*, 345 *Kansas St., El Segundo, Calif.*

For more information circle **294** on inquiry card.

MINIMAL-SPACE SUPPLIES

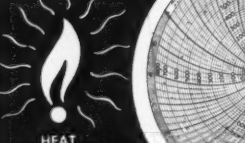
New "Models 281, 281M, 282 and 282M" have a panel height of 5¼"; are rated for 200 ma, 125-325 vdc for

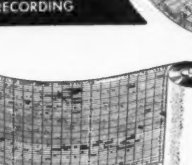


"281" and 281M," and 325-525 vdc for "282" and 282M."—*Lambda Electronics Corp.*, 11-11 131*st St., College Point* 56, *N. Y.*

For more information circle **295** on inquiry card.

CHARTS of all types





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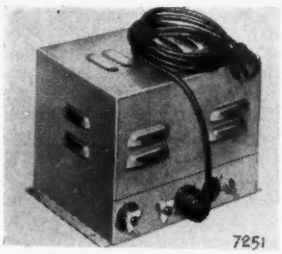
McDONNELL *Aircraft Corporation*

PORTABLE POWER SUPPLY

New "Model C-1450" is said to be "the first fixed/mobile design offered for amateur and commercial communi-



cations equipment." Three primary circuits enable user to power equipment from 6- or 12-v vehicular ignition systems or from 117-vac lines; dc output up to 250 v at 100 ma for receiving and dual output of 500 v at 175 ma and 250 v at 75 ma for transmitting. When powered from 117 vac it also supplies up to 10 amp for filaments at 6 or 12 v.—*James Vibrapowr Co., 4050 N. Rockwell St., Chicago 18, Ill.*

For more information circle **296** on inquiry card.

RECTIFIERS

TWIN-DIODE RECTIFIER

New "Vac-u-Sel" twin diode miniature rectifier, for use as a horizontal phase detector in place of 6AL5 tubes in TV sets, will find other applications; is especially adapted for automatic assembly operations using printed circuits; costs about half as much as tube it replaces, will last many times longer than this tube, is far more rugged and resistant to breakage.—*Rectifier Dept., General Electric Co., Lynn, Mass.*

For more information circle **297** on inquiry card.

SILICON POWER RECTIFIERS

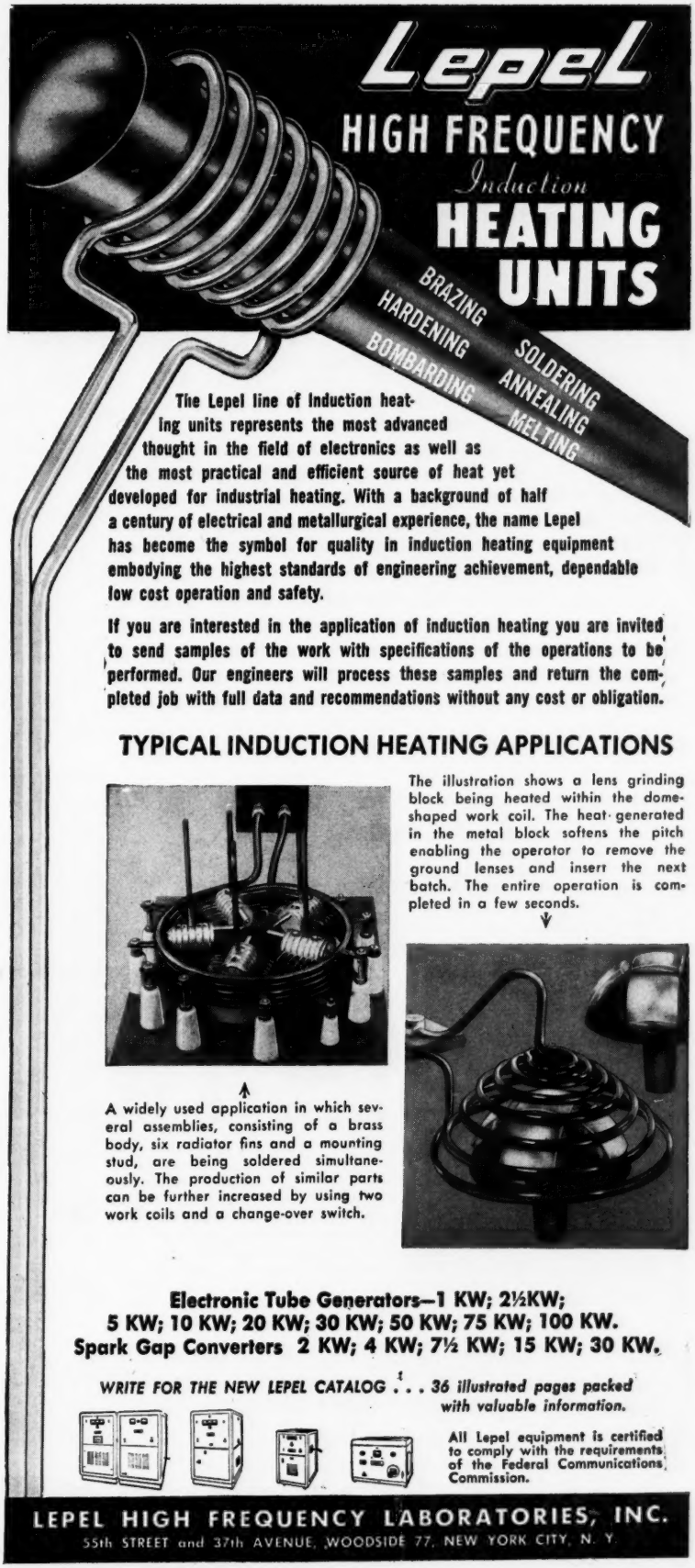
New "Types IN503 through IN526," featuring an exceptionally large power handling capacity for their size, can operate with extremely high reverse voltages and accompanying low reverse currents, and in ambient temperatures up to 125°C (257°F) owing to their inherently low thermal resistance.—*CBS-Hytron Div. Columbia Broadcasting Systems, Danvers, Mass.*

For more information circle **298** on inquiry card.

AMPLIFIERS

TRANSISTOR AMPLIFIERS

Two new oscilloscope preamplifiers incorporating "hushed transistor" principle: "VS-64A" ac amplifier has less than 0.45 uv rms noise voltage referred to shorted input terminals over a 60 kc pass-band; has an upper and a lower band-pass limiting switch making possible selection of restricted



The Lepel line of induction heating units represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating. With a background of half a century of electrical and metallurgical experience, the name Lepel has become the symbol for quality in induction heating equipment embodying the highest standards of engineering achievement, dependable low cost operation and safety.

If you are interested in the application of induction heating you are invited to send samples of the work with specifications of the operations to be performed. Our engineers will process these samples and return the completed job with full data and recommendations without any cost or obligation.

TYPICAL INDUCTION HEATING APPLICATIONS

The illustration shows a lens grinding block being heated within the dome-shaped work coil. The heat generated in the metal block softens the pitch enabling the operator to remove the ground lenses and insert the next batch. The entire operation is completed in a few seconds.

A widely used application in which several assemblies, consisting of a brass body, six radiator fins and a mounting stud, are being soldered simultaneously. The production of similar parts can be further increased by using two work coils and a change-over switch.

Electronic Tube Generators—1 KW; 2½KW; 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.
Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

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For more information circle **82** on inquiry card.

NEW INSTRUMENTS

band coverage between 3 db limits of amplifier which are 2 cps and 180 kc. ★ "VS-63A" direct-coupled dc amplifier outperforms vacuum-tube amplifiers not only by having substantially less noise but also by having unusually small drifts. Band-pass is 125 kc, adjustable in 9 steps to a minimum of 300 cps.—*Volkers & Schaffer Mfg. Corp., P. O. Box 996, Schenectady, N. Y.*

For more information circle **299** on inquiry card.

MIXER AMPLIFIER

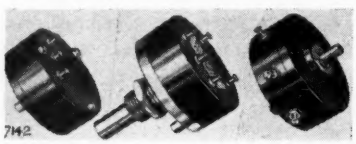
New "Model JG2 Transistorized Mixer Amplifier" is said to be "the first truly portable unit of its kind . . . ideal for remote-pickup recordings, outside public-address systems, and on-the-spot interviews." Entirely self-contained; including a 13-v power supply which will accept any of a wide variety of standard mercury cells, it comprises two low-noise preamplifier stages, one low-noise mixer stage, one amplifier stage, and one output stage.—*Baird Associates, 33 University Rd., Cambridge 33, Mass.*

For more information circle **300** on inquiry card.

ELECTRICAL COMPONENTS

LOW-COST PRECISION VDR

New "Series G-20 Precision Potentiometers" are voltage-dividing resistors said to be "designed to give



true precision at a new low price." Among features: linearity 0.5% or better; radial or rear extension turret terminals; non-metallic housing material of high dimensional stability, fungus-proof and moisture-resistant; power rating 1.5 watts at 65°C (de-rated to 0 at 150°C).—*The Gamewell Co., Newton Upper Falls 64, Mass.*

For more information circle **301** on inquiry card.

SIMPLIFIED-PHASING VDRs

New "Vari-Phase Precision Potentiometers" feature a simplified method of phasing multi-section voltage-dividing resistors: permit external independent phasing of each sectional cup without affecting phase relationships of others in group. Moreover, phasing can be accomplished after mounting in equipment, by loosening a clamping nut, moving terminal board in desired direction, then retightening. No clamping rings to hold cups, hence reduced over-all diameter. Available in ⅞", 1 1/16", 1⅝", 2" and 3" diameters.—*Clarostat Mfg. Co., Dover, N. H.*

For more information circle **302** on inquiry card.

SUBMINIATURE VDR

New "Model 78 Sub-Miniature Precision Potentiometer" is a voltage-dividing resistor of the carbon-film type, offering virtually infinite resolution and capable of operating at 150°C. Case diameter ⅞". Features include ball bearings, precious-metal pickoffs and precision synchro type mount. Additional cups can be ganged with a starting torque increase of only 0.02 oz-in per cup. Resistances from 500 to 500,000 ohms; linearities to 0.2%; wide variety of functional types.—*Computer Instruments Co., 1964 Utica Ave., Brooklyn 34, N. Y.*

For more information circle **303** on inquiry card.

Unique design of the two-dimensional Model D-2 features—Single micrometer adjustment controls vertical depth of cut, and adjusts height of copy table and pantograph.

Range of ratios from 2 to 1 to infinity!

Accessibility on three sides permitting panels up to 30" diameter to be engraved, milled or profiled. Vertical range over 10" allowing operations on complete chassis, cabinets or other bulky objects.

Ruggedness, stability and precise accuracy inherent in construction.

Mounted on the ruggedly constructed heavy duty steel Green Engraver Bench. All functional parts are conveniently within reach of the operator while seated. Accessibility of master type sets stored in lower cabinet trays, tools and accessories contribute to productive capacity.

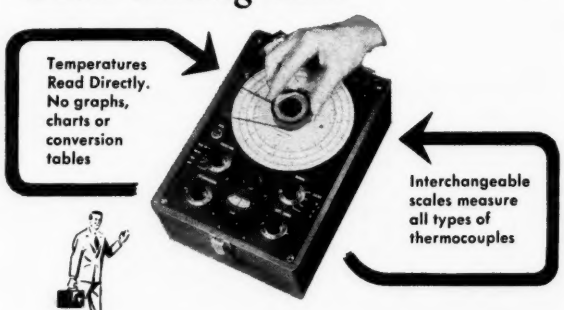
A brochure with full details is yours upon request.

Literature also available on the smaller Model 106 three-dimensional engraver.

GREEN INSTRUMENT COMPANY
383 Putnam Ave., Cambridge, Mass.

For more information circle **83** on inquiry card.

The only portable potentiometer pyrometer with interchangeable direct-reading scales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"Pyrotest" is the most versatile instrument of its type. Compact, rugged, easy to carry (12 lbs. . . . 12¼" x 9" x 8½"). Accurate to ¼ of 1%. 5 instruments in one—with a scale for every use, interchangeable in 30 seconds. Self-contained power supply. Write for free Bulletin 112.

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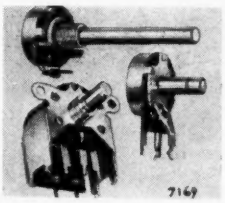
For more information circle **84** on inquiry card.

VOLUME CONTROLS FOR GRAPHIC CIRCUITS

New line of carbon volume controls includes types for mounting directly on circuit panel, self-supporting snap-

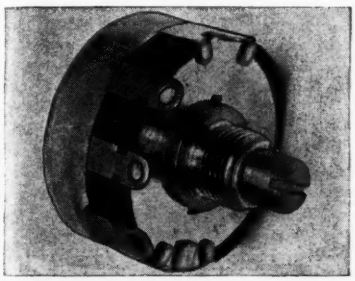


in models for top-of-panel mounting, and threaded-bushing types. Mounting tabs and terminals are accurately positioned to assure correct assembly by automatic production machines. Units can be supplied with maker's new line switch that utilizes "floating ring" contact action.—*P. R. Mallory & Co., Inc., Indianapolis, Indiana.*

For more information circle **304** on inquiry card.

WIRE-WOUND CONTROLS FOR GRAPHIC CIRCUITS

New 2-watt variable resistor, for use in printed-wiring assemblies, has terminals that facilitate mounting

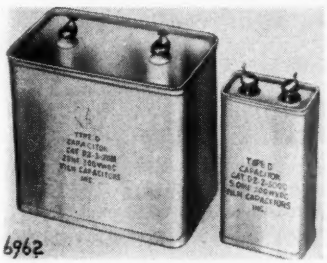


and connections. Tap is mechanically positioned 180° from center terminal, but can be electrically positioned to any percentage of resistance desired. Resistance values from 1 ohm to 50,000 ohms.—*Clarostat Mfg. Co., Dover, N. H.*

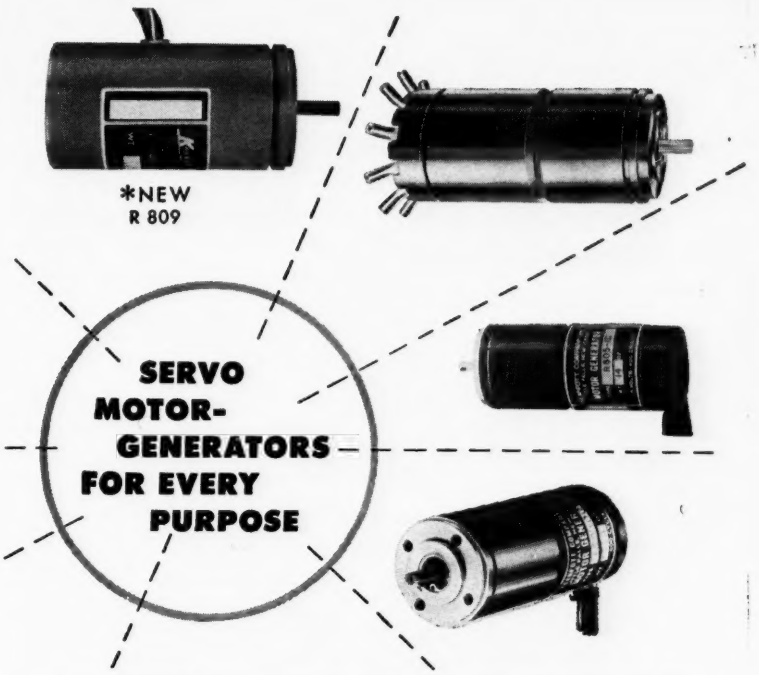
For more information circle **305** on inquiry card.

SEALED CAPACITORS

New "Type-D" low-priced moderately-small capacitors feature extremely high insulation resistance; at



least 10^6 megohms per microfarad at room temperature; also dielectric absorption of 0.1% superior to oil and wax paper). Ratings 100 to 600 v



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**New Size 11 low cost, Servo Motor-Damping Generator Type R 809,*

CHARACTERISTICS

TYPE	MOTOR		GENERATOR	
	STALL TORQUE	NO LOAD SPEED	OUTPUT FUND. NULL	LINEARITY
DAMPING				
SIZE 10	.35 OZ. IN.	6000	21/1	.5%
SIZE 10	.30 OZ. IN.	8500	23/1	.5%
NEW R 809	.63 OZ. IN.	5900	25/1	.5%
SIZE 15	1.5 OZ. IN.	5000	25/1	.5%
SIZE 18	2.4 OZ. IN.	5000	25/1	.5%
SIZE 18	3.0 OZ. IN.	9600	23/1	.5%
RATE				
SIZE 15	.45 OZ. IN.	10,500	170/1	.5%
SIZE 15	1.5 OZ. IN.	4700	350/1	.2%
SIZE 18	2.4 OZ. IN.	4700	350/1	.2%
SIZE 18	3.0 OZ. IN.	8400	350/1	.2%
*INTEGRATOR				
SIZE 15	.70 OZ. IN.	6300	400/1	.1%
SIZE 15	1.25 OZ. IN.	4500	400/1	.1%
SIZE 18	1.35 OZ. IN.	7200	400/1	.1%
SIZE 18	2.4 OZ. IN.	5200	333/1	.06%
SIZE 18	3.0 OZ. IN.	8000	333/1	.06%

*Integrator Tachometers are temperature stabilized

Kearfott components satisfy all requirements for high accuracy, light weight and small size.

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For more information circle **85** on inquiry card.

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No Wave Form Errors

SINGLE RANGES from 1 ma full scale to 10 amperes full scale. Good from DC to 2 megacycles and higher.

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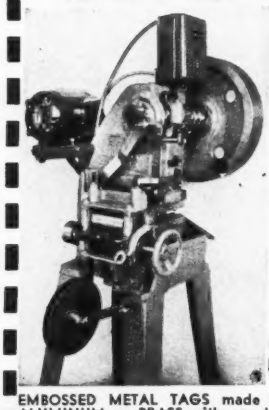
RAWSON ELECTRICAL INSTRUMENT COMPANY
112 Potter Street Cambridge, Mass

For more information circle **86** on inquiry card.

METAL
TAGS



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"The Original Marking Specialists"

For more information circle **87** on inquiry card.

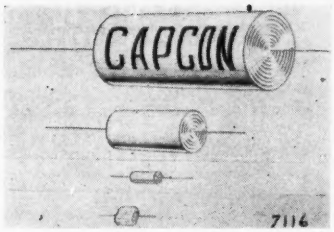
NEW INSTRUMENTS

with capacitance values up to 25 uf. No larger than corresponding oil paper capacitors.—*Film Capacitors, Inc.*, 3400 *Park Ave., New York* 56, *N. Y.*

For more information circle **306** on inquiry card.

HIGH-TEMP CAPACITORS

New "uncased Mylar" plastic-film capacitors are said to be available "in sizes smaller than any other miniature capacitors, and at very low prices." They operate dependably at temperatures up to 200°C (392°F)



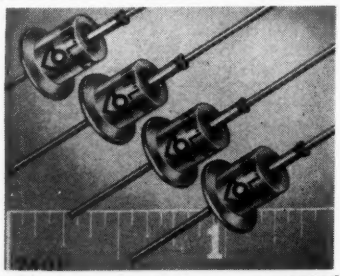
and are claimed to equal or exceed best technical features of conventional equivalent-rated paper-dielectric and other cased types.—*Capcon, Inc.*, 25 *Willett St., New York* 2, *N. Y.*

For more information circle **307** on inquiry card.

ELECTRONIC COMPONENTS

SILICON POWER DIODES

New silicon power diodes are rated for 300 ma dc rectified output current when mounted by leads in free air at



ambient temperatures up to 100°C. When mounted on cooling fins, they can be rated for 1.25 amp rectified output current at a case temperature up to 150°C.—*International Rectifier Corp., El Segundo, Calif.*

For more information circle **308** on inquiry card.

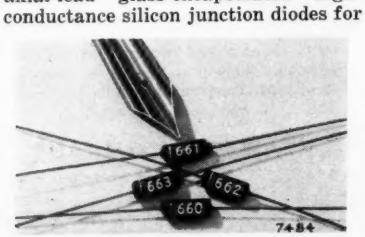
POWER TRANSISTORS

Six new germanium power transistors for handling up to 20 watts input are *p-n-p* power junction type; originally developed to meet US Signal Corps specs. Types are available for nominal 12- and 28-v operation. Collector is electrically connected to metal housing but, where it must be insulated from chassis, a large mounting flange permits rapid heat flow through insulating material.—*Clevite Transistor Products*, 241 *Crescent St., Waltham* 54, *Mass.*

For more information circle **309** on inquiry card.

SILICON JUNCTION DIODES

New "Types 660, 661, 662 and 663" axial-lead glass-encapsulated high-conductance silicon junction diodes for

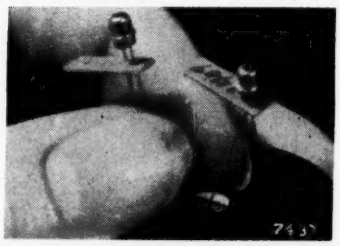


use in precise signal rectification have wide application in circuits requiring high uniform forward currents and extremely low back currents at elevated temperatures. At 150°C ambient, all four types have forward current ratings of 25 ma and reverse currents of 30 ua. At 25°C, 100 ma forward and 0.1 ua reverse.—*Texas Instruments, Inc.*, 6000 *Lemmon Ave., Dallas* 9, *Texas.*

For more information circle **310** on inquiry card.

SUBMINIATURE TRANSISTOR

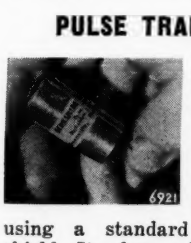
New "M-1," believed to be the smallest transistor yet developed (more than 20 can be placed on a dime) is of



p-n-p type; operates in AF range; performs functions of large-size transistors; withstands 20,000 *G;* is housed in a hermetically-sealed metal can.—*Philco Corp., Gov't & Ind'l Div.*, 4700 *Wissahickon Ave., Philadelphia, Pa.*

For more information circle **311** on inquiry card.

PULSE TRANSFORMER



New "Type PT-100" miniature encapsulated unit plugs into a miniature Noval socket; can be shielded and retained in place by using a standard miniature tube shield. Its four windings are insulated from one another and can be connected in various ways for impedance matching. It can be used in blocking oscillator circuits: diagrams and data available from maker.—*Berkshire Laboratories*, 682 *Bank Village, Greenville, N. H.*

For more information circle **312** on inquiry card.

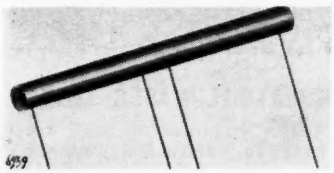
COMMUNICATIONS FILTERS

New line of communications filters comprises various types, frequency characteristics and impedance matches to clarify all types of keyed audio signals. Units are especially designed for minimum "ringing" or "tailing" and for best results under dynamic conditions.—*H. O. Boehme, Inc.*, 915 *Broadway, New York* 10, *N. Y.*

For more information circle **313** on inquiry card.

DELAY LINES

New "Custom-built Delay Lines" are specifically designed to meet electrical and mechanical requirements of

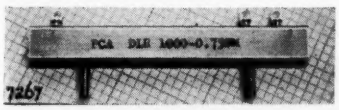


printed circuits; are said to "provide maximum delay/rise-time ratio for extremely low cost," can be supplied in rectangular or tubular housings with leads at any angle; operate from —55°C to 125°C.—*ESC Corp.*, 534 *Bergen Blvd., Palisades Park, N. J.*

For more information circle **314** on inquiry card.

SQUARE SEALED DELAY LINES

New hermetically-sealed delay lines, in 0.4" maximum square metal tubing, are provided with No. 20 tinned cop-



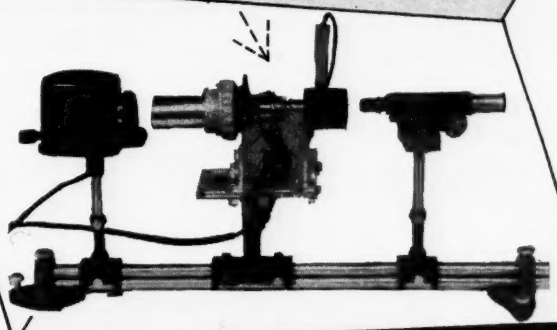
per wire for use in printed circuits; are available in each impedance level and delay time. One design emphasizes maximal delay per cubic inch with a fair rise-time; second combines moderate delay per cu in with good rise-time; third emphasizes fast rise-time and a low delay per cu in.—*PCA Electronics Inc.*, 2180 *Colorado Ave., Santa Monica, Calif.*

For more information circle **315** on inquiry card.

FLEXIBLE COAX SECTION

New 3⅛" UHF flexible coaxial section makes it possible to isolate shock-mounted gear from its associated rigid

a new approach to the problems of instrumentation



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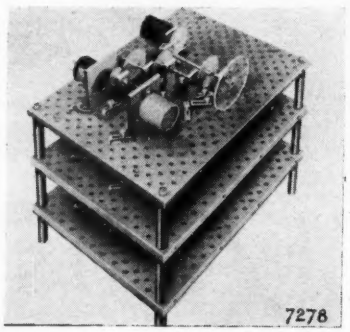
transmission line in an increased number of radar and communication systems; is useful also in complex rigid transmission lines for either absorption of large mechanical tolerance buildup, expansion and contraction, or misalignment between rigidly-mounted mating flanges.—*Airtron, Inc., Dept. B.*, 1103 *West Elizabeth Ave., Linden, N. J.*

For more information circle **316** on inquiry card.

ELECTROMECHANICAL COMPONENTS

ASSEMBLY KITS

New "Servoboard Electromechanical Precision Assembly Kit" has been completely revamped by addition of

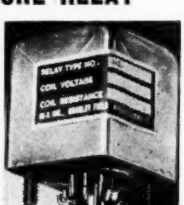


five times as many new parts. Fourteen component hangers prebored to various sizes; four blank hangers; gears previously available as only "solid-hub" components are now available as split hub gears; adapter gears, mitre gears, bevel gears and anti-backlash gears have been added to the list. Bearing hangers, dial assemblies, shaft adapters, couplings, terminal assemblies, a handcrank, magnetic clutches, a differential (with various end gears) and inertia load discs are included.—*Servo Corp. of America*, 20-20 *Jericho Turnpike, New Hyde Park, L. I., N. Y.*

For more information circle **317** on inquiry card.

SUBMINIATURE RELAY

New hermetically sealed relay measuring 1" square by 1 3/64" high surpasses applicable portions of MIL-R-5757C. Operating temperatures to 125°C; long life at rated contact

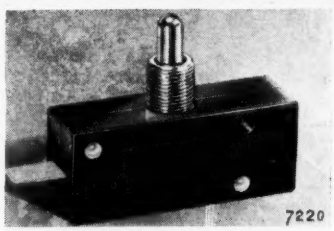


load of 2 amp 28 vdc or 115 vac. Coil resistance 50 to 10,000 ohms. Form A, B or C contact arrangement with a maximum of two poles.—*Hi-G, Inc., Bradley Field, Windsor Locks, Conn.*

For more information circle **318** on inquiry card.

LIMIT-TYPE SWITCH

New "Model 750 Snapac" features a new and improved switching mechanism which provides longer life; has a liberal overtravel, total travel ¼" to ⅜", hence recommended where actuating motion cannot accurately be controlled. Rating (UL) 15 amp 125

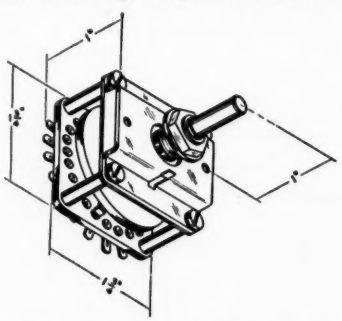


vac, 10 amp 250 vac, ½ hp 125/250 vac. Available circuits include sp-st normally open or closed and sp-dt. Suitable for limit, safety-interlock and control applications.—*Controls Corp. of America*, 9555 *Soreng Ave., Schiller Park, Ill.*

For more information circle **319** on inquiry card.

MINIATURE WAFER SWITCH

New "Miniature Series" rotary switches for instruments, computers, RF switching, etc., are available in

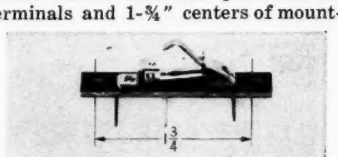


both shorting and non-shorting types with one to four poles per deck and two to 32 positions per deck. Up to six decks can be ganged.—*Shallcross Mfg. Co., Collingdale, Pa.*

For more information circle **320** on inquiry card.

SNAP SWITCH

New "S 2500 Series open type snap-action switch features quick-connect terminals and 1-¾" centers of mount-



ing holes which make it a standard replacement for present solder terminal models. It is available in many combinations of actuator arm configurations, operating forces, and electrical ratings to 10 amps, ⅓ hp.—*Cherry Electrical Products Corp.*, 1650 *Deerfield Road, Highland Park, Ill.*

For more information circle **321** on inquiry card.

AIRCRAFT CONNECTOR

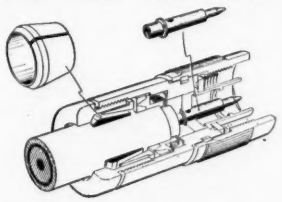
New "Super-16" features a "hooded" front construction that makes impossible the entrance of oversize test

probes. Feature is light weight: on an average fighter plane about 5 lb will be saved.—*American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.*

For more information circle **322** on inquiry card.

COAXIAL CONNECTORS

New advanced design "N Series Coaxial Connector" combines high frequency range (10,000 Mc) and

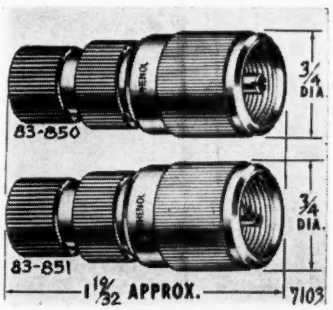


weather-proofing with such new and desirable features as a collet clamping device, and locked-pin contact. —*Diamond Div., Cannon Electric Co., 7 North Ave., Wakefield, Mass.*

For more information circle **323** on inquiry card.

UHF CONNECTORS

New "83-850" completely solderless, and "83-851" semi-solderness, UHF plugs eliminate operation of soldering



cable braid to connector shell and, being re-usable, are suitable for lab and service use where they can be assembled and disassembled for different projects.—*American Phenolic Corp., Chicago 50, Ill.*

For more information circle **324** on inquiry card.

MOTORS, etc.

MINIATURE DC MOTOR

New "Moto-Mite" miniature woundfield dc motor can be wound shunt, series, or split series. Armatures, bearings and brush assemblies are interchangeable with maker's PM dc motors. Armature windings are available for a wide variety of speed and torque characteristics. Either spur or

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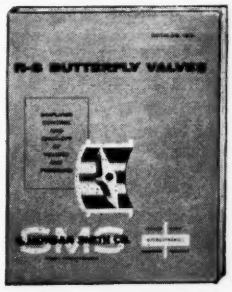

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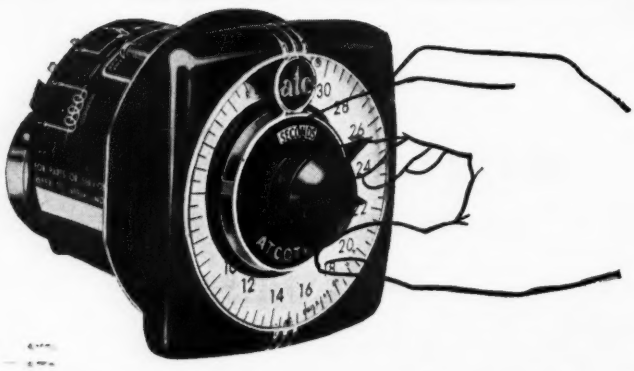
For more information circle **89** on inquiry card.

Why have orders for this unique miniature timer increased 496% in the last year?



. . . because Atcotrol is years ahead in benefits for both the installer and the user. Only by seeing Atcotrol performance, can you fully realize all its advantages.

All terminals face the rear and are protected by an arc barrier to facilitate wiring and eliminate possibility of shorts. One piece terminal block is made of strong acrylic resin, fibre-glass reinforced.

Large, vertical silver contacts assure cleanliness and non-burning, low resistance conductance. Good contact wiping action.

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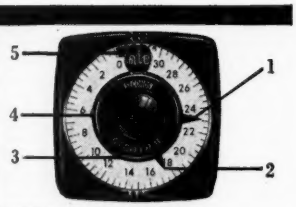
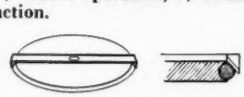


FIVE OPERATIONS CHECKED BY OBSERVING TIME FACE

1) Total cycle time, 2) elapsed time, 3) motor operation, 4) clutch operation, 5) switch action.



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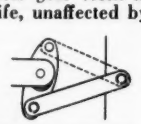
Unique, non-slip clutch with infinite engagement points eliminates gear teeth mesh. Long life, unaffected by wear.



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For more information circle **90** on inquiry card.

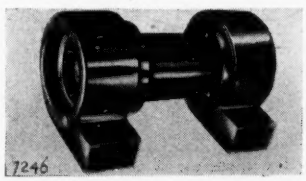
NEW INSTRUMENTS

planetary gear trains can be used as gear reduction. A governor is available, as is a brake. Rating 1/200 hp continuous duty and 1/75 hp intermittent duty.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton* 4, *Ohio.*

For more information circle **325** on inquiry card.

MINIATURE MOTORS

New "1200 Frame" dc motors, especially designed for use in airborne accessory equipment, are miniature

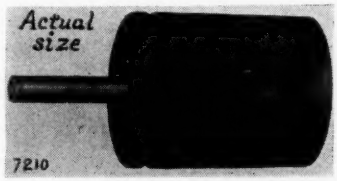


permanent-magnet units; 5000 to 22,000 rpm; ratings of 1/300 to 1/75 hp; are said to "feature voltage outputs ranging from 6 to 28 volts." Illustration shows blower application.—*Induction Motors Corp.*, 570 *Main St., Westbury, L. I., N. Y.*

For more information circle **326** on inquiry card.

MOTOR GEAR HEAD

New "Model 750-GH" ultraminiature precision motor gear head for adaptation to Size 8 motors weighs

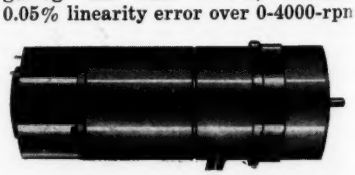


1⅛ oz; is 0.750" in dia. and, in its "solid type" model, 1" long; features low starting torque (0.004 oz-in); ratios up to 650:1 without increase in length (up to 20,000:1 in longer units).—*Bowmar Instruments Corp.*, 2601 *Pennsylvania St., Fort Wayne, Ind.*

For more information circle **327** on inquiry card.

AC MOTOR-TACHOMETER

New high-precision 400-cps miniature ac motor-tachometer, originally designed for airborne precision integrating and rate servos, features 0.05% linearity error over 0-4000-rpm



range, 0.05% scale error over ambient temperature range of −55°C to 75°C; and 400-cps null voltage is reduced to virtually zero (less than 1 mv in phase and quadrature). Output at 3600 rpm is 3.6000 volts within 0.05% and is in phase with excitation voltage within 0.05°. Tachometer has a built-in heater and thermostatic control.—*Precision Components, Inc., 65 Rushmore St., Westbury, L. I., N. Y.*

For more information circle **328** on inquiry card.

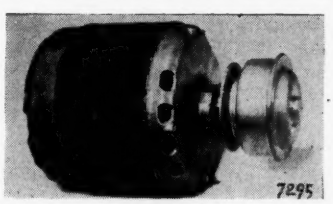
TORQUE SOLENOIDS

New "Pacsol" snap-action torque solenoids meet rigid military and aircraft requirements; are furnished in a broad range of performance characteristics—each a standard feature entailing no increased cost. Operating principle is conversion of axial magnetic pull into powerful rotary stroke by means of a compensated cylindrical cam and dual rollers. Advantages: Axial shaft movement being eliminated, there is no need to absorb linear shaft motion. Units can be coupled direct to load without intervention of splines or complicated linkages. Any degree of shaft travel is supplied, from 5° to 60° rotation, in increments as small as 1°, without extra tooling charge. User can obtain any torque curve needed. Torque values up to 15 lb-in or more, in a unit measuring 1 1/8" D x 1 3/8" L.—*Pacific Solenoids, Inc., 208 Standard St., El Segundo, Calif.*

For more information circle **329** on inquiry card.

FLUID DRIVE

New "Willo Fluid Drive," for use with FHP motors, is said to incorporate desirable features hitherto un-



available in this type of power transmission unit, and to provide full 100% efficiency. No slippage while under full load. Safety protection against shock overloading results from employing a unique torque conversion principle. Permanently sealed housing obviates need for servicing.—*Will-O-Hill Industries, Inc., 37611 Euclid Ave., Willoughby, Ohio.*

For more information circle **330** on inquiry card.

AIR MOTOR

New air motor is of constant-displacement rotary-vane design; weighs 1½ lb and develops 2¾ hp per 100 psi of inlet pressure (limit about 300 psi). Over-all efficiency approaches 70% at speeds between 3000 and 6000 rpm. Qualified for missile applications over ambient range of −20°F to 160°F and accelerations of

SIE **MODEL C-6**

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DIRECT READING FROM 0 OHMS TO 10,000,000 MEGOHMS

- 3 TEST VOLTAGES: 1½, 50, 500 VOLTS
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MODEL 40 KEYBOARD provides a convenient means for plotting large amounts of tabular data in point-curve form. Self-contained voltage source together with full three column keyboard in both X and Y axes; unit plugs directly into MODEL 2 AUTOGRAF.

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MODEL 30 CARD TRANSLATOR converts information from punched cards into point form for automatic plotting. Handles up to 50 cards per minute, 10 to 200 counts per inch. Plugs directly into MODEL 2 recorder, controls both card reader and recorder for completely automatic operation.

Bulletins describing these instruments are available and we'll be glad to send them to you.

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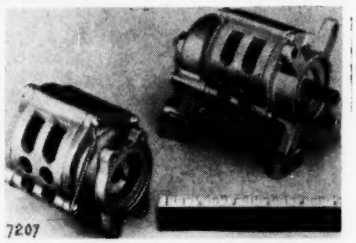
For more information circle **92** on inquiry card.

NEW INSTRUMENTS



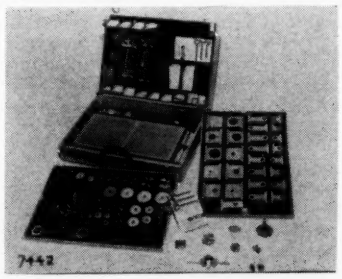
60 *G;* withstands inlet gas temperatures in excess of 1000°F for as long as two minutes; requires no in-line lubrication. Motor on right contains a unique governor which maintains speed constant within 2% for load transients of 10%.—*Bendix Pacific Div.*, 11600 *Sherman Way, No. Hollywood, Calif.*

For more information circle **331** on inquiry card.

MECHANICAL COMPONENTS

BREADBOARD KITS

New kits comprise gears, shafts, differentials, breadboard plates, hangers, bearings, etc. Kit "D" has 655



pieces; "F" has 518 and "S" has 425. All gears are fine-pitch series, 96 pitch, 20° pressure angle, ⅛" shaft size.—*PIC Design Corp.*, 160 *Atlantic Ave., Lynbrook, L. I., N. Y.*

For more information circle **332** on inquiry card.

POWDERED-METAL GEARS

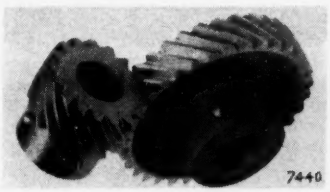
New gears, made from powdered metal by a new improved process, equal or surpass conventional cut

gears in performance, wearing patterns and accuracy. Their cost is 30% below that of cut gears.—*A. A. Specialty Gear Co.*, 12327 *Edwin Ct., Cleveland* 12, *Ohio.*

For more information circle **333** on inquiry card.

HELICAL SPUR GEARS

New "Type A6" precision helical spur gears are immediately available from stock in three bore sizes ⅛", $\frac{3}{16}$",

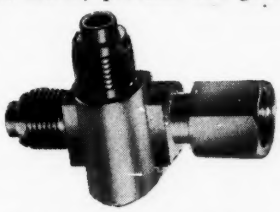


and ¼" with 20 to 80 teeth in both stainless steel (clear passivated) and aluminum (chromic acid anodized).—*PIC Design Corp.*, 160 *Atlantic Avenue, Lynbrook, L. I., N. Y.*

For more information circle **334** on inquiry card.

DUAL-DRIVE ADAPTER

New "Circle Ess" dual drive adapter is used in conjunction with flexible shaft drives; provides two gear ra-

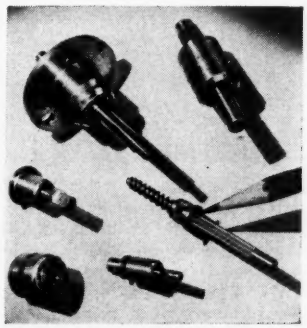


tios from the same power source; is equipped with threaded connections having 0.104" internal square drives and in ratios of 1:1, 15:1, 16:1 and 17:1 for either left or right rotation. Body is aluminum alloy with brass connectors; hardened steel gears run in oil-lite bearings which are permanently lubricated for high and low temperatures. Weight 4 oz.—*F. W. Stewart Corp.*, 4311 *Ravenswood Avenue, Chicago* 13, *Ill.*

For more information circle **335** on inquiry card.

BALL BEARING

New "Versa-Twin" is a unique type of double-row unground ball bearing in which parts of the machine or other end product are used to form the inner and outer races. Applications are said to be practically unlimited but bearings must be engineered into the redesign of an existing product or into the design of a new product. Inner race can be customer's product



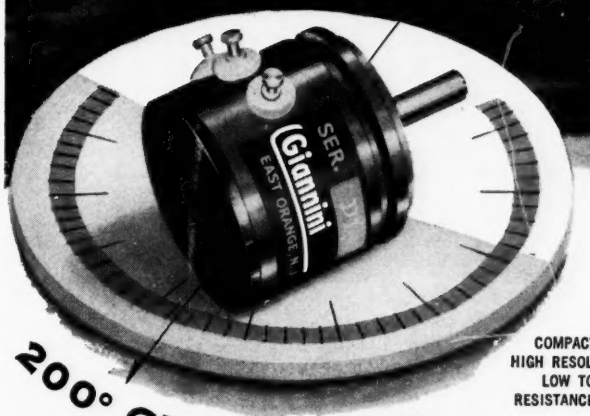
Giannini Potentiometer Innovations

low-torque Microtorque

** infinite resolution Spiralpot*

and now...

** hi-temperature 875T*



other features:

COMPACT—⅞" DIAMETER
HIGH RESOLUTION—TO 0.6%
LOW TORQUE—1 OZ. IN.
RESISTANCE TO 100K OHMS

200° CENTIGRADE

Giannini has created a completely new potentiometer to work hand in hand with today's rapid advancements in electro-mechanical systems. The Giannini 875T high temperature potentiometer, recommended for applications requiring high power accommodation at elevated temperatures, is capable of continuous operation at temperatures to 200°C and is constructed to dissipate two watts at 150°C. In addition to its outstanding thermal characteristics, this precision potentiometer offers the precise linearity and fine resolution usually associated with much larger instruments.

875T—the most significant milestone in potentiometer achievement since the introduction of Giannini's infinite resolution "Spiralpot"—rounds out the definitive line of Giannini electro-mechanical products which also includes the well known ultra-low torque "Microtorque." Just as these instruments are unique in their respective categories, it is anticipated that the 875T will similarly become *the* standard for high power, high temperature applications.

Giannini *ELECTROMECHANICAL DIVISION*

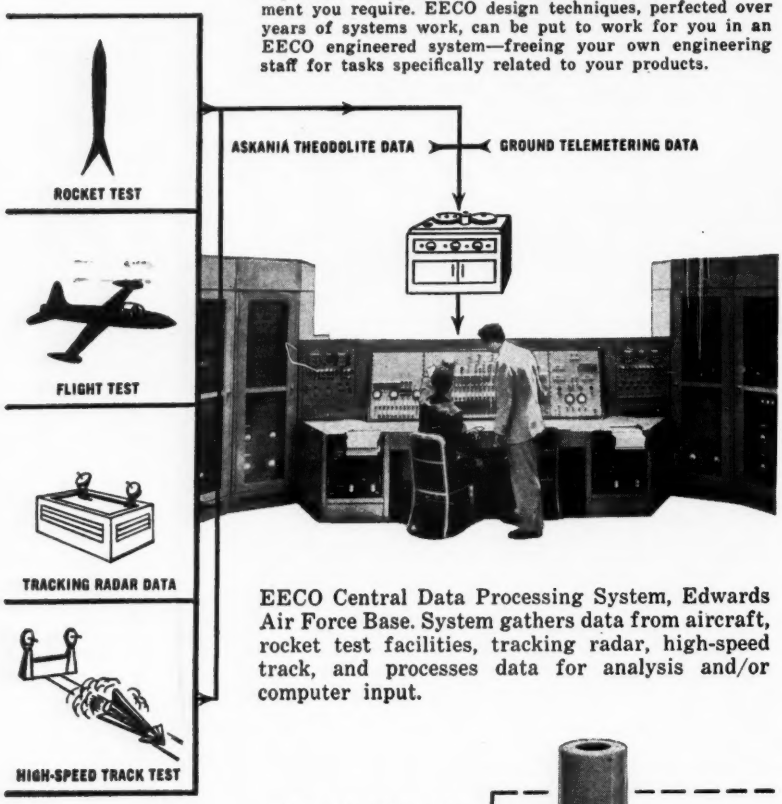
G. M. GIANNINI & CO., INC. • 918 E. GREEN ST., PASADENA, CALIF.

For more information circle **93** on inquiry card.

FOR SYSTEMS

see . . . EECO

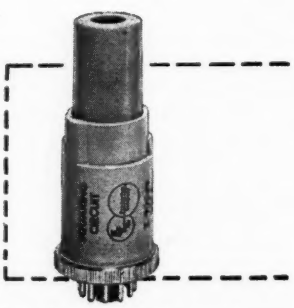
From a single-rack recording system to a multi-console data processing center, Electronic Engineering Company has the experience and personnel to design and produce the equipment you require. EECO design techniques, perfected over years of systems work, can be put to work for you in an EECO engineered system—freeing your own engineering staff for tasks specifically related to your products.



EECO Central Data Processing System, Edwards Air Force Base. System gathers data from aircraft, rocket test facilities, tracking radar, high-speed track, and processes data for analysis and/or computer input.

Plug-in Circuits

developed for EECO systems, provide a key to lower cost equipment design and fabrication. Data on standard and custom circuits available in catalog



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For more information circle **94** on inquiry card.

NEW INSTRUMENTS

shaft, an adaptation of it, or a shaft fitted to a part; outer race, too, can be a functional component. "Versa-Twin" offers great stability and is double-acting, because it can carry both radial load and thrust load in both directions, locking moving parts into desired axial position. Specific friction factor 0.0015. Practically any material or combination of materials. No definite limits on size, but bearing has been made to date in sizes ranging from $\frac{3}{16}$ OD x $\frac{3}{16}$" L to about 1½" OD.—*Hartford Steel Ball Co., 12 Jefferson Ave., West Hartford 6, Conn.*

For more information circle **336** on inquiry card.

VALVES, etc.

VERSATILE ¼" VALVES

New ¼" "D Pilotair Valves" are suitable for use as directional valves, interlocking valves, transfer valves, sequence valves or shut-off valves in pneumatic control systems with pressures as high as 250 psi and temperatures as high as 200°F. Sectionalized construction permits over 3,000 different 2-, 3- and 4-way valves to be assembled from a few basic parts. Valves can be operated manually, pneumatically, mechanically or electrically. When desired, two operators (not necessarily of same type) can be assembled on the same valve.—*Westinghouse Air Brake Co., Wilmerding, Penn.*

For more information circle **337** on inquiry card.

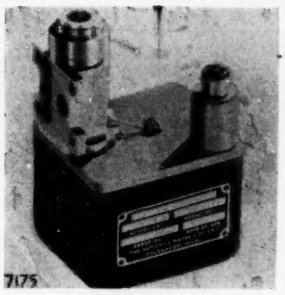
PRESSURE REGULATING VALVE

New "Type 3381" pressure reducing and regulating valve is 5-⅝" high and 2⅝" face to face; controls air, water, oil, steam and most liquids and gases. Body and trim are bronze, seat and diaphragm are bronze or composition. Sizes are ¼" and ⅜" with screwed ends (⅛" on special order). Valve can operate at inlet pressures as high as 400 psi at 150°F and 250 psi at 400°F. Five spring ranges are available for delivery pressure from 5 to 300 psi.—*A. W. Cash Co., P. O. Box 551, Decatur, Ill.*

For more information circle **338** on inquiry card.

METERING VALVE

New single-stage torque-motor-driven valve converts an electrical signal to a straight-line gradient response for hydraulic or pneumatic applications. Pressure 0 to 1500 psi; hysteresis 3% maximum; differential input 20 ma maximum; coil resistance 1570



ohms ± 5%; delivery 150 cu in per minute at full current differential.—*National Water Lift Co.*, 2220 *Palmer Ave., Kalamazoo, Mich.*

For more information circle **339** on inquiry card.

SOLENOID-CONTROLLED VALVE

New two-way direct-solenoid-controlled valve features "in-line" construction which makes it easy to inspect and service. All control parts can be removed in one small assembly without disturbing piping, by loosening one hexagonal nut. Primarily for ac applications; pressure and vacuum; normally-closed; available in standard pipe sizes from ¼" through 2".—*Airmatic Valve, Inc.*, 7317 *Associate Avenue, Cleveland 9, Ohio.*

For more information circle **340** on inquiry card.

SOLENOID VALVES

New solenoid valves have synthetic diaphragm that "floats" free, providing greater fluid flow at lower pressure differentials than do preceding models; are pilot-operated with no metal-to-metal contacts to wear; are guaranteed for eighteen months. Operate satisfactorily with any pressure differential between and 1 and 250 psi; are available in a wide variety of sizes with port openings from 7/64" to 1½" dia; screw, solder, or flare connections. Coil assemblies for all valves are interchangeable.—*Division C, Jackes-Evans Mfg. Co.*, 4427 *Geraldine Ave., St. Louis* 15, *Mo.*

For more information circle **341** on inquiry card.

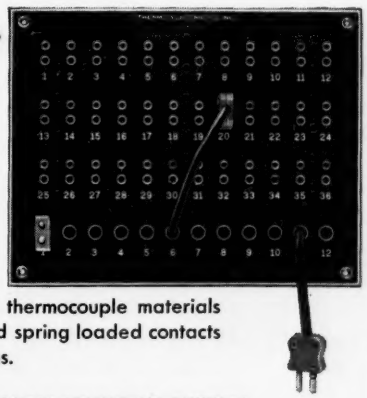
QUICK-ACTION VALVES

New "Quick-Dump" flow control valves, said to incorporate a basic improvement in design, are intended for

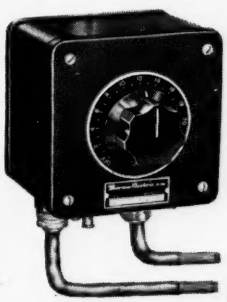
SWITCHING MANY THERMOCOUPLE OR RESISTANCE BULB CIRCUITS?

Temperature measuring applications are like tracks in a freight yard—they often need plenty of quick switching. Achieving both measuring accuracy and speed — especially with frequent switching — requires a system well suited to the individual circuit. Among Thermo Electric's four methods is one best suited to *your* needs.

QUICK-COUPLING CONNECTOR PANELS



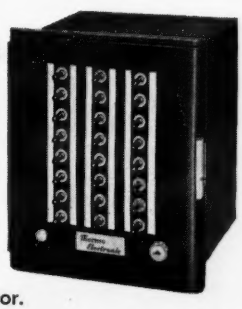
Provide great flexibility for transferring numerous thermocouples—ideal for patch panel use. Many compact shapes and sizes. Panel for 48 thermocouples and 16 pyrometers measures only 13¼ x 7⅞". Polarized plugs and jacks of standard thermocouple materials have long-wiping surfaces and spring loaded contacts for good electrical connections.



ROTARY SELECTOR SWITCH

For quick checking or switching of thermocouples or resistance bulbs. "Shorting-type" switches designed for flush panel or wall mounting. Contacts and wipers of same silver alloy. Three models have OFF to 6, 12 and 24 points.

KEY SWITCHES



Provide a choice of connecting many sensing elements to one instrument or transferring sensing elements from one type of instrument to another. Locking or non-locking construction.

PUSH-BUTTON SWITCHES

For on-off checking of temperatures from many points or averaging any number of temperatures on one indicator.

Single Case Construction | 12-72 points for push buttons, 12-144 for keys.

Write for Bulletins | Connector Panels No. 23-F; Rotary Switches No. 24-100-F; Key and Push-Button Switches No. 24-1-F

Thermo Electric Co., Inc.

SADDLE BROOK, NEW JERSEY

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For more information circle **95** on inquiry card.

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More and more people are turning to us for electroplated wire. We electroplate by continuous methods a wide variety of wire in a range of diameters from .035" to the smallest available. In our laboratory, Tungsten wire as small as .00015" has been electroplated with Gold . . . New applications for electroplated wires on different base materials are being developed from time to time . . .

Your inquiry is invited. Consult our staff, without obligation, about your specific wire problems.

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For more information circle **96** on inquiry card.

BALL and SOCKET DESIGN

INFINITELY STRONGER

DAHL "DEMI"® TOGGLE ACTUATED VALVE

*Giving credit where credit is due, we offer the "Ball and Socket" principle in our toggle actuated two-way and three-way "DEMI" valves.

The two-way "DEMI" valves are PACKLESS. The three-way "DEMI" Valves are available in the packless design with all three ports piped or with one port vented to the atmosphere. Bodies are stocked in brass, anodized aluminum, steel and stainless steel. The internal parts can be supplied in materials for corrosive or non-corrosive service for pressures to 200 psi. The toggle itself is case hardened steel and cadmium plated and defies rough treatment.

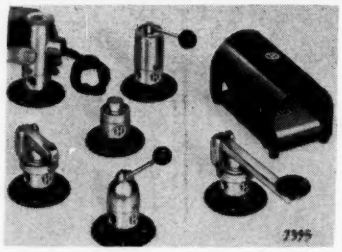
Write for Complete Catalog and Name of our Representative in your area.

GEORGE W. DAHL CO. INC.

BRISTOL • RHODE ISLAND

For more information circle **97** on inquiry card.

NEW INSTRUMENTS



use in equipment or applications that require either manual or automatic valving of air, water, oil or freon. Basic valve body can be used N-O or N-C. To this body can be added a variety of simple devices for triggering valve action. Opening, closing and holding action are effected by pressure of controlled medium. Because valving action works with pressure instead of against it, it is claimed that all performance characteristics are enhanced. (Mfd by General Gas Light Co.)—*Humphrey Products, 202 N. Park St., Kalamazoo, Mich.*

For more information circle **342** on inquiry card.

FOUR-WAY VALVES

New "Model 40" four-way valve is added to maker's line of solenoid-operated pneumatic and hydraulic valves.

As with maker's shut-off and three-way versions, new four-way valves are available for shipment within 24 hours. Tube sizes from ¼" to ½" are available.—*Mar Vista Engineering Co., 5420 W. 104th St., Los Angeles 45, Calif.*

For more information circle **343** on inquiry card.

PRESSURE-REDUCING VALVE

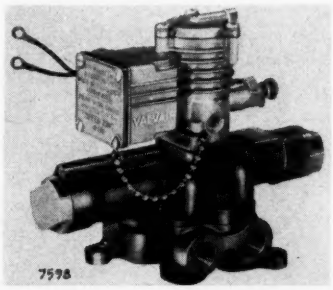
New "Class GPK" air-loaded diaphragm-operated pressure-reducing valve for steam heat and process steam applications has only two mov-

ing parts: a unique metal diaphragm with full valve travel and a hardened stainless steel main valve that seats on a renewable Stellited seat ring. A simple air loader replaces conventional loading spring and produces a constant loading force on diaphragm: design assures the same control point over full valve travel. Available in CI in sizes ½" to 2", with screwed end connections. Inlet pressure range 0-250 psi, 450°F.—*Leslie Co., Lyndhurst, N. J.*

For more information circle **344** on inquiry card.

SOLENOID-&-PILOT VALVES

New "Speed King" solenoid pilot-operated control valves meet or exceed JIC Pneu. Std. pars. A2.5.8 and

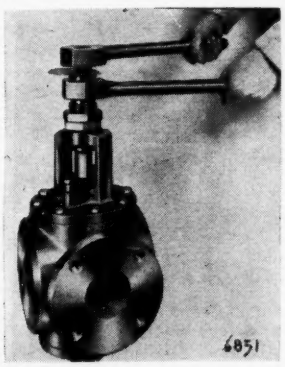


A6.4. JIC features include sealed solenoid enclosure, safety solenoid cover which renders valve inoperative when cover is removed, and integral junction box large enough to accommodate 6" taped pigtail leads. Manual override permits operation of valve with electrical power off. Service life exceeds 25 million cycles under normal operating conditions.—*Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.*

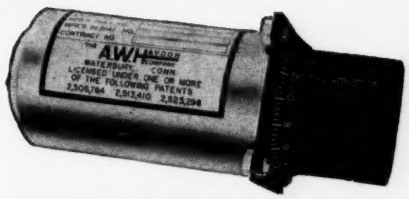
For more information circle **345** on inquiry card.

PLUNGER SEATING VALVE

New "Plug Valve" handles abrasive slurries and solids in suspension—cement, sand, coal, food products,



plant waste, and chemical sludges—as well as oil, gases, and chemicals. Construction is somewhat similar to simple plug valve, except that seating force on plug is applied manually. Turning torque is low since plug is turned only after being raised from its seat. Plug is coated with tough



precision components pay off in performance

THE A. W. HAYDON CO. SPECIAL TIME DELAY RELAY never gives in to severe vibration, shock or sustained acceleration. Positive detent arrangement maintains time setting under all conditions. Large adjusting knob facilitates changing of time setting. Stepless clutch drive minimizes clutch error.

SPECIFICATIONS

1.* Voltage Range: 24-29 Volts DC at 68°F.

2. Accuracy over Calibrated Range of adjustment:
   (a) ±0.1 second or ±1% of setting, under condition 1.*
   (b) ±0.15 second or ±2% of setting, over wide temperature range.

3. Meet Military Specs. for temperature, altitude, sand and dust, fungus, salt spray, radio filtering.

4. Vibration: 5-55CPS with total excursion 0.060".

Current ratings at 29 Volts and room temperature:

1. Motor— 25 Milliamps
2. Clutch— 200 Milliamps
3. Contacts— 1.0 Amp Inductive

Time delay period can be adjusted in 2/10 second increments over range of 0.2—30 seconds. (Catalog on Request)

PREFERRED WHERE PERFORMANCE IS PARAMOUNT

The A. W. HAYDON Company
Design and Manufacture of Electro-Mechanical Timing Devices

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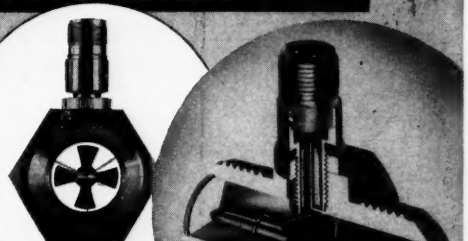
For more information circle **98** on inquiry card.

for PRECISE Flow Measurement in TOUGH APPLICATIONS...



Waugh
TURBINE FLOW METERS
offer these exclusive features to satisfy your exacting flow measurement requirements:

- Measure trickles (.065 GPM) or torrents (6000 GPM) to ½% of flow rate.
- Pressure drop is low (2.5 to 4.5 psi) at full rated flow in standard models—even lower in others.
- Simple rugged design permits maintenance-free operation under extremes of temperature, vibration and pressure.
- Light-weight turbine rotor instantly reacts to changes in flow rate, permitting accurate transient measurements.

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A wide variety of flow rate indicators and recorders, and flow totalizers are available.

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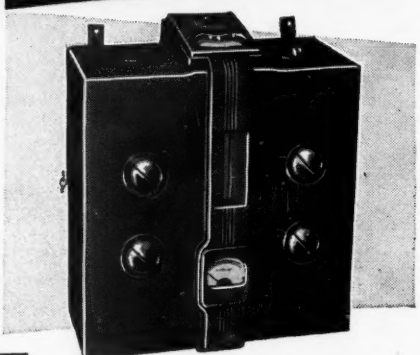
For more information circle **99** on inquiry card.

practical and accurate

for measuring oxygen or hydrogen present as impurities in other gases

the durably constructed

DEOXO INDICATOR



The DEOXO INDICATOR permits a continuous and accurate reading of minute quantities of oxygen or hydrogen.

This equipment offers optimum efficiency within the range of .001% to 1.000% for oxygen and .002% to 2.000% for hydrogen.

A self-contained calibrating unit is included as an integral part of this unit. If desired, the DEOXO INDICATOR can be connected to controllers and recorders.

Write for additional data, technical assistance.

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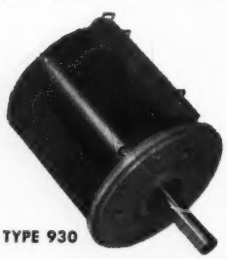


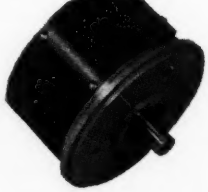
TYPE 930

Now, for the first time, the sustained accuracy of all-metal case construction is available in 10-turn and 3-turn potentiometers. These multi-turn units are capable of withstanding the severe environmental conditions required by military specifications and provide the user with high accuracy, reliability and long life.

ALL-METAL CASE CONSTRUCTION IN 10-TURN AND 3-TURN POTENTIOMETERS

The Types 930 and 933 are 1.812 in. diameter. In the Type 930 a linearity tolerance of ±0.05% is standard with linearity to ±0.025% for resistance of 2K ohms and greater. In the Type 933 the standard linearity tolerance is ±0.10%, with ±0.05% available in resistances of 10K ohms and above. Mechanical and electrical rotations are 3600° for Type 930, with standard tolerance of −0°, +4° or in special cases, −0°, +1°. For Type 933, rotations are 1080°, with standard tolerance of −0°, +4° and special tolerance of −0°, +1°. Furnished with all standard mountings. Flexibility of design makes it possible to supply many types of special mechanical and electrical features.

TYPE 933



SAMPLES AVAILABLE ON ORDER

Fairchild's complete line can help solve all your precision potentiometer problems. For more information write Fairchild Controls Corporation, Components Division, 225 Park Avenue, Hicksville, L. I., N. Y. Dept. 140-65B3.

FAIRCHILD **PRECISION POTENTIOMETERS and COMPONENTS**

For more information circle **101** on inquiry card.

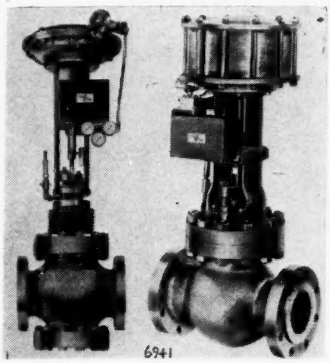
NEW INSTRUMENTS

synthetic rubber for positive leakproof seal. Oil or grease is unnecessary for sealing or to reduce friction; hence no contamination of products passing through valve, and no routine servicing required.—*Republic Mfg. Co.*, 15655 *Brookpark Road, Cleveland* 11, *Ohio.*

For more information circle **346** on inquiry card.

CONTROL VALVES

New diaphragm-actuated "Type CV-D" and piston-actuated "Type CV-P" control valves are designed to



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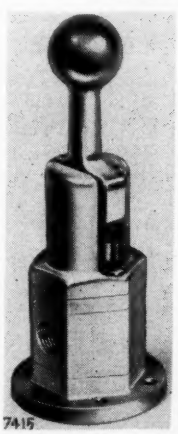
handle all fluids at unlimited pressures. "CV-D" can be direct or reverse in action. "CV-P" is simple in design and easy to maintain, has extreme rangeability and its piston actuation force can deal with static and dynamic unbalances and with stuffing-box friction.—*Copes-Vulcan Div., Blaw-Knox Co., Erie, Pa.*

For more information circle **347** on inquiry card.

PILOT VALVES



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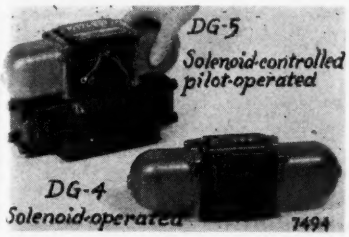
Five new pilot valves, added to maker's line, include hand, foot, palm-button, cam and solenoid-actuated types in a variety of mountings. New hand valve, available in either locking or non-locking type, can be used singly or in series for working pressures up to 150 psi. New foot valve has generous treadle area. New palm-button valve, especially suitable for panel mounting, returns to normal position when button is released. New solenoid valve with instantaneous action is easily and quickly removed without tools. New cam valve features a built-in overtravel which prevents damage when a series of cams operates valve.—*Mechanical Air Controls, Inc.*, 10030 *Capital, Oak Park, Detroit* 37, *Mich.*

For more information circle **348** on inquiry card.

DIRECTIONAL VALVES

New line of solenoid-operated and solenoid-controlled pilot-operated directional valves for industrial oil-hy-

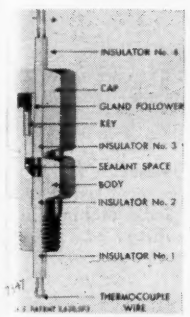


draulic systems features ample room in valve body for making electrical connections, thereby obviating need for a separate conduit box. New valves are improved models of maker's "DG Series," are available for gasket or sub-plate mounting, require a minimum of piping. Another new feature is an override plunger which permits manual operation of valve during setup operations, circuit checks or solenoid or current failure. And new chain prevents loss of covers during solenoid maintenance or adjustment.—*Vickers Inc.*, 1400 *Oakman Blvd., Detroit* 32, *Mich.*

For more information circle **349** on inquiry card.

MISCELLANEOUS

TC GLAND SEALANT



New "Lava Sealant" for maker's thermocouple glands is natural fired magnesium silicate; is furnished in a preformed plug machined to fit into sealant cavity of maker's glands of 1, 2, 4, 6, or 8 wire capacity. Sealant is compressed between two porcelain insulators under a pressure of 50,000 to 100,000 psi; is forced against wires, insuring positive seal in pressures from full vacuum to 20,000 psi in operating conditions of −300°F to 1850°F.—*Conax Corp.*, 7811 *Sheridan Drive, Buffalo* 21, *N.Y.*

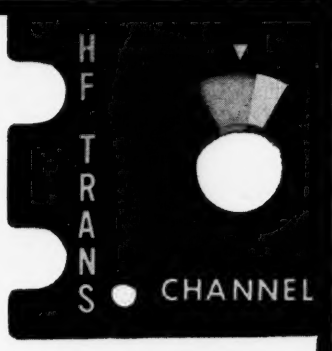
For more information circle **350** on inquiry card.

METAL DETECTOR

New "Universal Model" of maker's electronic metal detector, for protection of production equipment and product in rock crushing, mining, and cement operations, can be pre-set to detect unwanted metal ranging in size from chips to chunks. Among new features: (1) "Universal Model" is the first of its type with automatic drift control that holds detection sensitivity at a constant level regardless

have you
Edge Lighting Problems?

The unparalleled design flexibility of the Lackon® photo-marking process may offer you the best solution. With a minimum of gimmicks and gadgetry, Lackon® gives you a panel of unequalled marking accuracy, optimum legibility and lighting uniformity, with excellent resistance to severe environmental conditions. Designed, tested and quality controlled in our government approved laboratory, Lackon® edge lighted panels, knobs and knob skirts meet and exceed lighting, legibility and durability requirements of specification MIL-P-7788.



The Lackon® engineering staff of the United States Radium Corporation will readily assist your panel engineering department during the initial design stage. The cooperative application of their skill and experience in lighting techniques to your panel design will speedily resolve design difficulties, result in decided production economies, and yield a remarkably superior finished product. For information write Dept. IA-7

United States Radium Corporation

535 Pearl St., New York 7, N. Y.
Regional offices at: 4624 W. Washington Blvd., Chicago 44, Ill.; 5420 Vineland Ave., North Hollywood, Calif.; 36 Avenue Krieg, Geneva, Switzerland; Radelin-Kirk, Ltd., 1168 Bay St., Toronto 5, Ont., Canada

For more information circle **102** on inquiry card.

AC ELECTRONICS DIVISION

NEEDS HYDRAULIC RESEARCH ENGINEERS

To Develop TEST FACILITIES for Jet Engine Fuel Control Systems and Components.

Working with: High Energy Fuels at Extremes of Temperatures and High Pressures

Test Stands
Environmental Test Cells
Remote Instrumentation

Servo Operated Afterburner Fuel Controls, Inlet Temperature and Turbine Speed Sensing Electro-Hydraulic Servo Controls.

Applicant should have B.S. Degree Plus 4-6 Years Experience Relative to Hydraulic Engineering, Valve Design, Hydraulic Servos, Instrumentation and Testing of Fluid Control Devices, or Other Associated Fields.—Write to Mr. J. Heffinger, Supervisor of Salaried Personnel

AC THE ELECTRONICS DIVISION

GENERAL MOTORS CORPORATION

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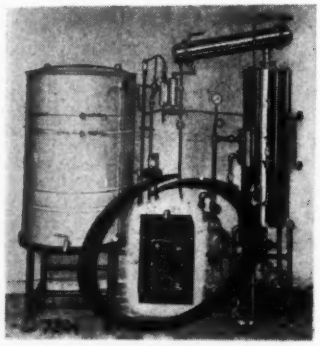
of temperature fluctuations. (2) Long tube life. In accelerated life tests, no tube change for periods comparable to more than two years, whereas comparable detectors require tube change every few weeks. (3) Heavy-duty bisectional aperture frame, constructed of marine mahogany, available in standard sizes up to 32" high and 72" wide; larger sizes to order.—*Radio Corp. of America, 30 Rockefeller Plaza, New York 20, N. Y.*

For more information circle **351** on inquiry card.

WATER PURITY CONTROLLER

New "Puromatic Controller" utilizes conductivity principle to control purity of distilled water automatically.

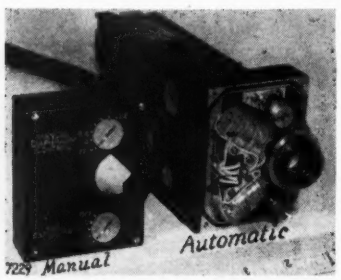


Operator sets desired standard of purity on controller and only water of that purity or higher is permitted to enter storage tank; water below preset purity is diverted to waste. Setting is adjustable on 0-15 ppm scale.—*Barnstead Still & Sterilizer Co., 244 Lanesville Terrace, Forest Hills, Boston 31, Mass.*

For more information circle **352** on inquiry card.

AUTOMATIC-EXPOSURE-TIME FIGHTER-PLANE CAMERA

New "KB-5" target-analysis or "gun" camera emulates human eye iris in that it automatically compen-

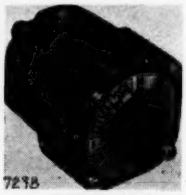


sates for changes in light conditions. Installed on supersonic jet fighter planes, it can be used to record details of aerial combat while nose of plane, in a "dog fight", may be pointed at sunlight sky and seconds later at a dark-shaded area of the earth.—*Fairchild Camera & Instrument Corp., Robbins Lane, Syosset, L. I., N. Y.*

For more information circle **353** on inquiry card.

AIR VOLUME BOOSTER

New "Series 2000" volume booster for pneumatic loading and gaging applications features rapid filling and exhausting, and maximum flow

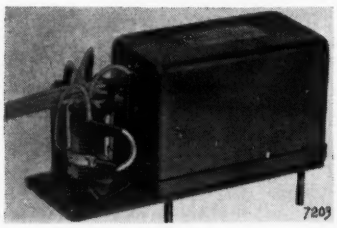


even at low pressure differentials—made possible by ⅜" dia supply and exhaust seats; will fill a 24" valve motor to 15 psi in less than 1 second with a 100-psi supply, and will exhaust to 3 psi in 3 seconds.—*Governaire Div., Bellofram Corp., Burlington, Mass.*

For more information circle **354** on inquiry card.

VOLTAGE REGULATORS

Three new types of ac voltage regulators for 30 kw engine-driven alternators are minimum-size units built

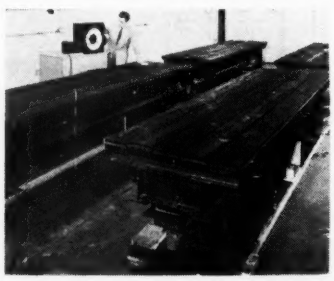


to military standards, encapsulated to MIL-T-27 specs; combine magnetic and transistor components. Standard models are designed to regulate line-to-neutral voltage of a 3-phase 4-wire 208-v generating unit.—*Arga Div., Beckman Instruments, Inc., 220 Pasadena Ave., So. Pasadena, Calif.*

For more information circle **355** on inquiry card.

TRAILER SCALE

New type of trailer scale will make it easier for highway truckers to meet highway limitations on axle and gross

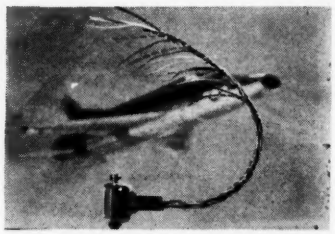


weight, as well as to keep every load close to 100% pay-load. It is intended primarily for use at loading docks of terminals operated by common carriers. It is an electrical scale with no moving parts under weighing platforms. Weight is measured by means of eight "SR-4" load cells, two of which support each of four platforms.—*Baldwin-Lima-Hamilton Corp., Cambridge, Mass.*

For more information circle **356** on inquiry card.

STRANDED HOOK-UP WIRE

New "Temprex" extruded-Teflon-coated hook-up wire for high temperature service (to 250°C or 482°F) is

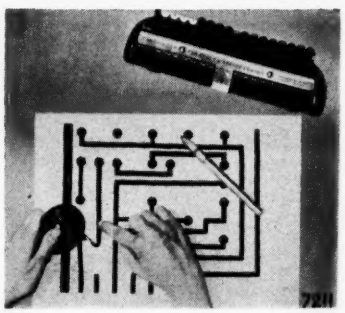


impervious to all known commercial solvents. Insulation remains unaffected by weathering, aging, fungus or moisture. Fourteen standard colors, innumerable combinations of 1 or 2 color stripes; sizes 26 to 10 AWG.—*Hitemp Wires, Inc., Windsor Avenue Mineola, New York.*

For more information circle **357** on inquiry card.

GRAPHIC-CIRCUIT-LAYOUT TAPES AND SHAPES

New features have been added to maker's line of self-sticking narrow tapes and terminal shapes. They in-

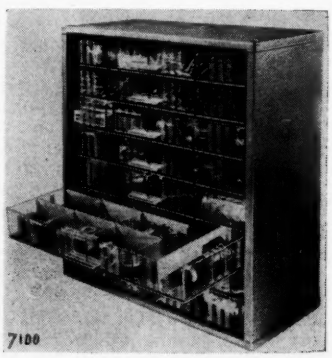


clude precision slit connector strips in rolls with 0.005" tolerance; using precut shapes for "splash etching" of prototypes; availability of stock shapes in 1/10" increments.—*W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis.*

For more information circle **358** on inquiry card.

UTILITY CABINET

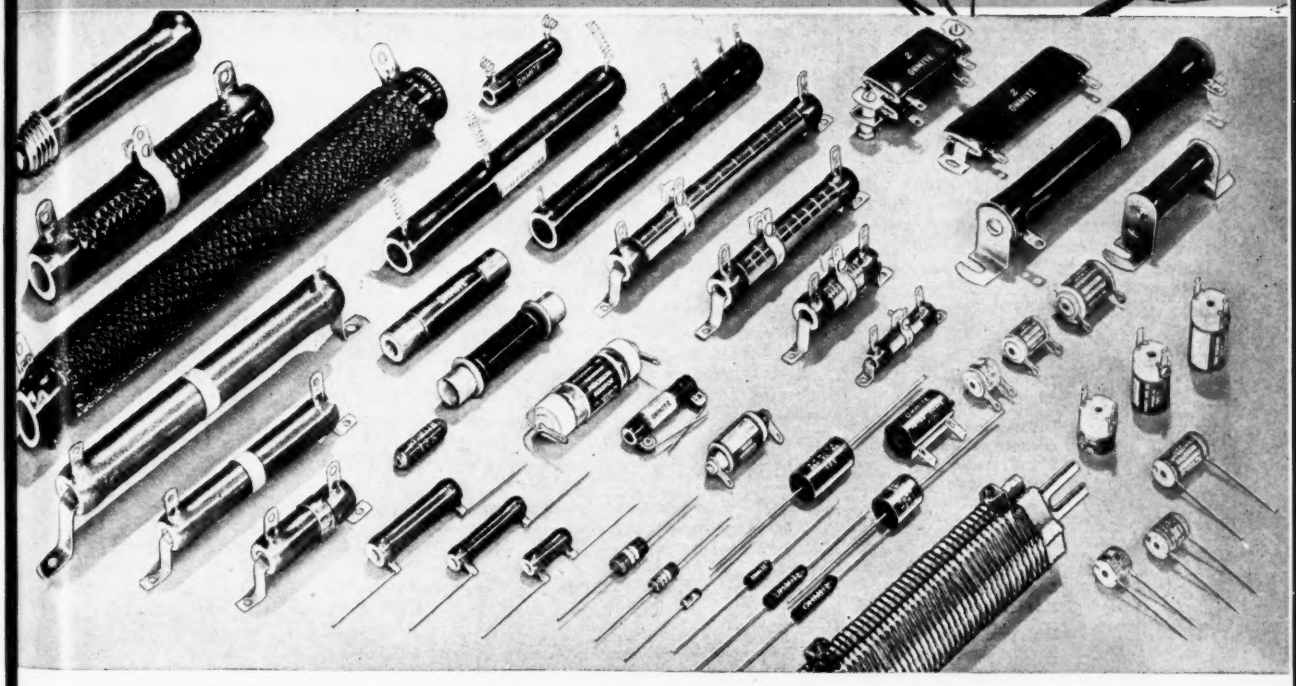
New "E Z Find Full Vue" cabinet keeps track of hundreds of little parts needed in shop, lab, etc. Ninety-six



OHMITE®

has exactly the resistor you need

Ohmite offers the most complete line of wire-wound resistors on the market . . . fixed, adjustable, tapped, non-inductive, and precision resistors in many sizes, types of terminals . . . in a wide range of wattages and resistances.



Industry's most complete line of wire-wound resistors!

The extensive range of Ohmite types and sizes makes possible an almost endless variety of Ohmite resistors to meet each individual need. Ohmite offers resistors in more than 60 sizes—ranging from 2½" diameter by 20" long to ¼" diameter by $\frac{9}{16}$" long—to meet your exact requirements. MANY SIZES ARE CARRIED IN STOCK. These rugged resistors have proved their quality under the toughest operating conditions. Ohmite application engineers will be pleased to help you in selecting the right resistors for your job.

Write on company letterhead for Catalog and Engineering Manual No. 40.

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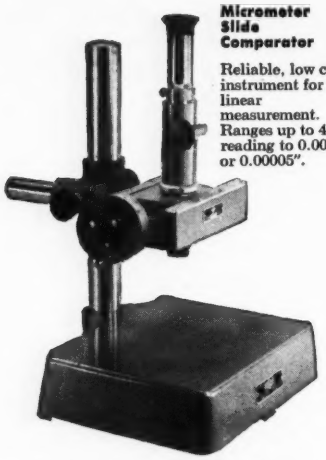
Be Right with **OHMITE®**

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES

For more information circle 186 on inquiry card.



Micrometer Slide Comparator

Reliable, low cost instrument for linear measurement. Ranges up to 4", reading to 0.0001" or 0.00005".

Gaertner measuring microscopes

Easy, sure measurement to 0.0001" cuts rejects and speeds production

Precise, versatile, easy-to-use Gaertner measuring microscopes assure positive, direct measurement of precision parts. You see clear, sharply-defined images. No physical contact to distort or injure object being measured. Enjoy new production savings with Gaertner optical instrumentation. Write for complete data on the Gaertner line of industrial microscopes.

Toolmakers' Microscope

Ultimate in measuring microscopes. Range 2" x 4", reading to 0.0001", angular measurement to 1 minute.

Coordinate Measuring Microscope

High precision, low cost instrument for 2-dimensional linear measurement. Range 2" x 2", reading to 0.0001".

Filar Micrometer Microscope

High quality, low cost instrument for extremely precise measurements. Range 0.08", reading to 0.00002".

Write for Bulletin 161-54 showing applications, models, specifications.

The Gaertner Scientific Corporation

1211 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

For more information circle **105** on inquiry card.

NEW INSTRUMENTS

different items can be stored in one cabinet, neatly indexed, dust-free, every item in plain sight. Each of the 32 drawers can be made into 2 or 3 lengthwise or crosswise compartments. Welded steel frame measures 14" high, 6" deep and 12½" wide.—*Akro-Mils, Inc., 820 E. Market St., Akron 9, Ohio.*

For more information circle **359** on inquiry card.

RAILWAY SIGNAL CIRCUIT

New "Audio Frequency Overlay (AFO)" circuit, for non-vital railway signaling applications, can be superposed on existing wayside signaling track circuits without mutual interference. Advantage is that no insulated joints are required for isolating this auxiliary circuit; and basic wayside signaling track circuit remains intact. Adjoining or even overlapping circuits can be provideo without interference. Principle: output of an a-f transmitter is applied directly to rails or line wires. A receiver, tuned to selected frequency, receives transmitted signal and operates relays or other circuitry.—*Union Switch & Signal Div. Westinghouse Air Brake Co., Pittsburgh 18, Pa.*

For more information circle **360** on inquiry card.

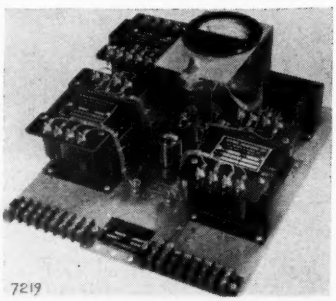
LAYOUT GRID PAPER

New layout paper with reproducible 0.1" grid is designed especially for easier drafting of printed-circuitry drawings; is of 12" x 24" sheet size; is available in lots of 100, 200 and 500 sheets.—*Photocircuits Corp., Engineering Dep't, Glen Cove, N. Y.*

For more information circle **361** on inquiry card.

MOTOR CONTROL SYSTEM

New "L C Servo-amp" automatically corrects for changes in motor load; is a closed-loop servo system which

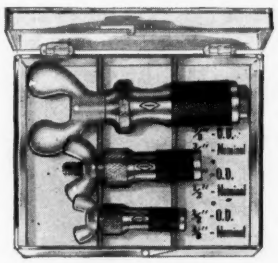


maintains (for example) a constant pressure between a tool and a workpiece. It is available as a "package" (open or enclosed) or with remotely-located instrument and/or auxiliary control. Electronic portion can be supplied as part of an automatic sequencing control system.—*Control Engineering Co., 8900 Alpine Ave., Detroit 4, Mich.*

For more information circle **362** on inquiry card.

TEST PLUG KIT

New "No. 142-F" set of 3 test plugs, for use in temporarily shutting off ½", ⅝" and ⅞" O.D. tubing

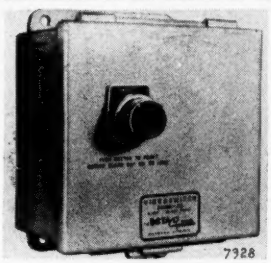


(⅜", ½" and ¾" nominal sizes), is packaged in plastic box with hinged lid. In use, tightening wing nut expands synthetic rubber portion and seals tube. Plugs will hold 100 psi.—*Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.*

For more information circle **363** on inquiry card.

VIBRATION-TYPE MECHANICAL MALFUNCTION DETECTOR

New model of "Vibraswitch" in oil-tight JIC enclosure monitors vibration and actuates an alarm or causes

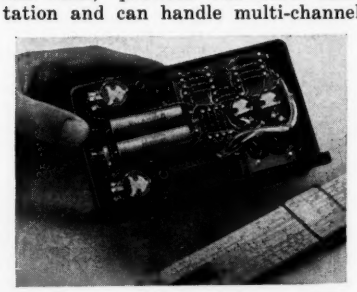


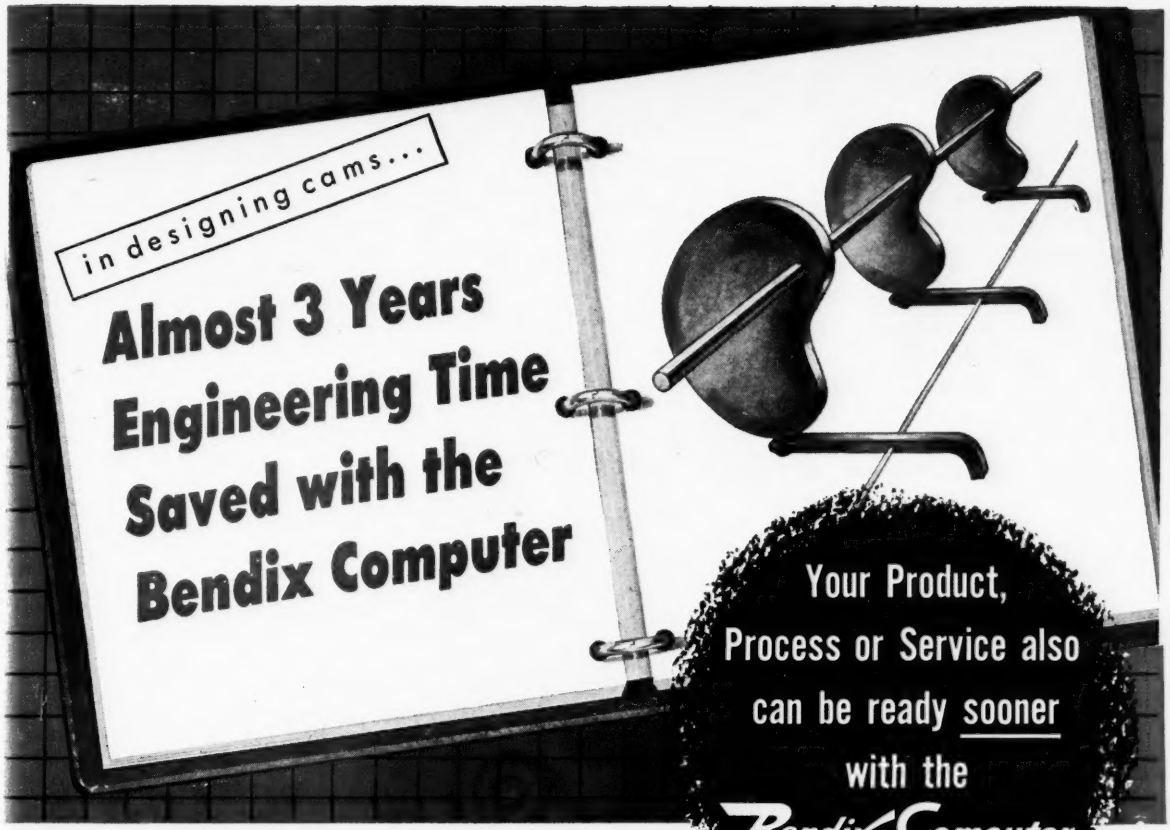
shutdown when trouble occurs in rotating or reciprocating equipment. It detects malfunctions such as bearing roughness, unbalance, broken blades, bent shafts, etc. Mechanism is fail-safe, does not depend on external power source, requires no maintenance. Wide range of adjustment.—*The Beta Corp., Forest Avenue at Ridge Road, Richmond 26, Va.*

For more information circle **364** on inquiry card.

DUAL SERVO BALANCER

New electronic unit, said to accomplish "essentially the same functions previously carried out by more cumbersome and expensive electromechanical units," provides transducer excitation and can handle multi-channel




in designing cams...
Almost 3 Years Engineering Time Saved with the Bendix Computer
Your Product, Process or Service also can be ready sooner with the Bendix Computer

Bendix General Purpose Computers are saving users untold years of engineering time. This **time-saved** factor, as in the cam designs described here, is the common denominator which makes the Bendix Computer so effective in every line of work where complex mathematical problems must be solved.

PROBLEM: To design 14 cams for control mechanisms. The radii (approximately 1400) of each cam were to be computed at even ¼° points with the radii accurate to the nearest ten thousandths of an inch.

CONCLUSION: (Directly quoted from the Bendix user) "Figuring conservatively, several hundreds of thousands of equations were solved in the 40 hours needed to run the cams on the Bendix G-15 Computer. It has been estimated that it would take an engineer about three years to do the same work and possibly a fourth year to find his mistakes. Computing with the G-15 not only cut the cost of the task; but, often more important, freed engineers for other work and enabled us to get the units on the market ahead of competitors."

The Bendix G-15 is a high speed, large capacity digital computer. Because of its low cost, users have found that the Bendix Computer can be written off in 3 years or less with the savings it can effect.

Bendix Computer

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5630 Arbor Vitae Street, Los Angeles 45, Calif.

Tell us how we can economically use the Bendix Computer in our engineering, research and control functions.

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Company_____ Address_____

For more information circle **106** on inquiry card.

RdF STIKON®

RESISTANCE THERMOMETER ELEMENTS

Eliminate Effect of Ambient Air Temperatures

Highly-stable RdF Stikons respond to changing temperatures quickly and accurately (to one-half a degree centigrade). Because of the element's thin construction (.005 to .010 inches), and the extremely close proximity of its temperature-sensitive grid to the measured surface, the effect of ambient air temperature is practically nil. When used in a bridge, *an RdF Stikon may easily produce output voltages several hundred times higher than the output of the most sensitive thermocouples.*

SUMMARY OF CHARACTERISTICS

Type	Resistance at 70°F (ohms)	Temperature Range F*
BN-1	81.7	—100° to +300°
BN-3	50.	—100° to +300°
BN-4	200.	—100° to +300°
PN-1	50.	—100° to +180°
PN-2	200.	—100° to +180°
SN-1	100.	—100° to +500°

* For continuous operation — may be used intermittently at higher temperatures. See RdF Stikon Brochure T-54.

Type	Wafer Material	Size (inches)
BN-1	Bakelite	½ x 1½ x .005
BN-3	Bakelite	5/16 x ¾ x .006
BN-4	Bakelite	5/16 x ⅛ x .006
PN-1	Paper	5/16 x ¾ x .006
PN-2	Paper	5/16 x ⅛ x .006
SN-1	Silicon-Glass	5/16 x 1 1/16 x .010

Types BN-1, BN-3 and PN-1 are marked to 0.2 ohms, while types BN-4, PN-2 and SN-1 are marked to 0.5 ohms.

Arthur C. Ruge Associates, Inc.

ACRA

733 CONCORD AVE
CAMBRIDGE 38, MASS

For more information circle **107** on inquiry card.

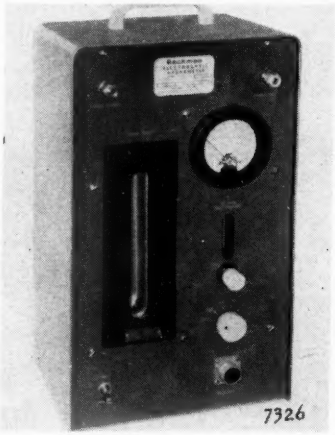
NEW INSTRUMENTS

inputs in either ac or dc form. Its outputs consist of sum of integral of input plus a signal proportional to amplitude of input. Outputs have a 0° and a 180° phase relationship to input. Proportional channel has adjustable scale factor and integral channel has adjustable time constant.—*Transvaal Engineering Corp.*, 10401 *Jefferson Blvd., Culver City, Calif.*

For more information circle **365** on inquiry card.

ELECTROLYTIC HYGROMETER

New electrolytic hygrometer capable of measuring one part of water in a million parts of air is based on

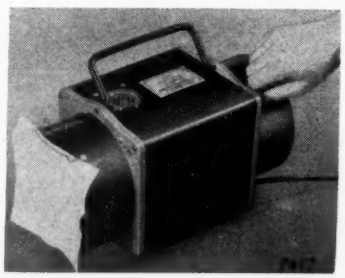


a du Pont design. It continuously measures water content of extremely low ranges in gas samples—an important factor in many applications for controlling corrosion, product purity and process efficiency.—*Process Instruments Dept., Beckman Instruments, Inc., Fullerton, Calif.*

For more information circle **366** on inquiry card.

AIR SAMPLER

New "Fixt-Flo Air Sampler" enables precise measurement of airborne contaminants taken from large sam-

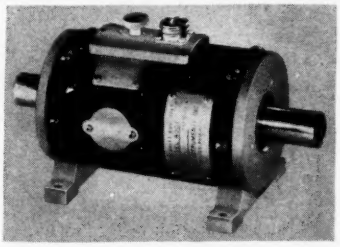


ples of air: is used to collect these contaminants to be weighed and analyzed in connection with industrial hygiene or air pollution problems. Feature is an automatic flow control which compensates for changes of filter resistance caused by collected material.—*Mine Safety Appliances Co.*, 201 *N. Braddock Ave., Pittsburgh* 8, *Pa.*

For more information circle **367** on inquiry card.

TORQUEMETER

New "Torquemeter" measures torque in rotating systems at high speeds; is a complete measuring sys-



tem comprising both electrical means for measuring a torsional strain, and a mechanical assembly for providing that strain. Torque shaft assembly ("Torquometer") complete with bearings and housing is inserted between driving source and load. A variable-inductance pickup measures twist angle of torque shaft which is proportional to torque. Output (100 mv full-scale) can be read on standard carrier amplifier equipment, chart recorders, or on maker's "Torquemeter Indicating System." Standard ranges from 100 lb-in full-scale to 5000 lb-in full-scale; others available.—*B & F Instruments, Inc.*, 4732 *N. Broad St., Philadelpia* 41, *Pa.*

For more information circle **368** on inquiry card.

COATED STEEL WIRE

New "Fernicklon" nickel-plated steel wire with up to 10% nickel coat can be used wherever combinations of strength, corrosion resistance and lustrous finish are desirable. ★ Brass-coated wire, available in sizes from 0.072" to 0.310", is recommended only for decorative effects.—*National-Standard Co., Niles, Mich.*

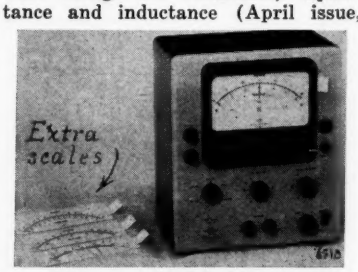
For more information circle **369** on inquiry card.

CORRECTIONS

Weinschel Engineering. "Model 210" Coaxial Attenuator (June issue, page 1160).—"Absolute accuracy at 400 Mc . . ." should read "Absolute accuracy at 4000 Mc at room temperature 0.1 db of nominal value."

* * *

Brush Electronics Co. Deviation Test Bridge for resistance, capacitance and inductance (April issue,



page 756).—Photo showed instrument only; manufacturer now sends us photo "that should be used in any future publicity regarding Model BL-1506 Deviation Test Bridge."

Saved in 12 months:

2 man-years of data-reduction time

In designing the Air Force's giant C-130 "Hercules" Transport, Lockheed Aircraft's Georgia Division tested model after model . . . . measured stresses at up to 500 points per wing as loadings were gradually increased in the test jig. Just a few short years ago, the resulting mountain of raw data would have been a serious stumbling block to the development program. But with the aid of a specially designed Consolidated Automatic Data-Processing System, Lockheed engineers were able to slash data-reduction time to the bone. In just one year's operation, it saved *two man-years of data-reduction time!*

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just a few of the system's unusual operating features . . .

. . . balances and reads out up to 200 strain-gage channels at an average rate of 25 channels per minute. Capacity can be increased through additional commutation.

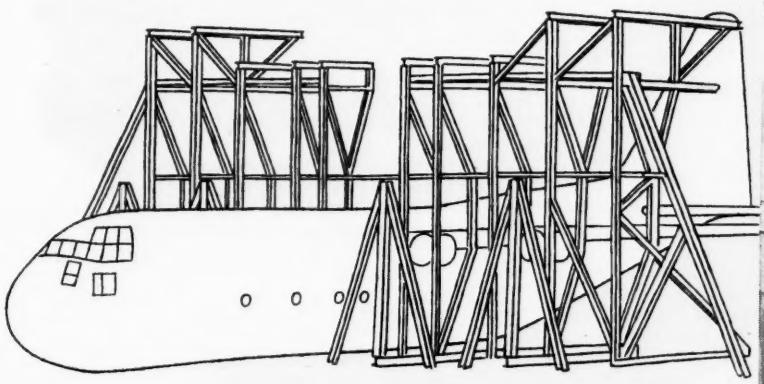
. . . automatically tabulates true, corrected values, in pounds, psi, degrees, etc.

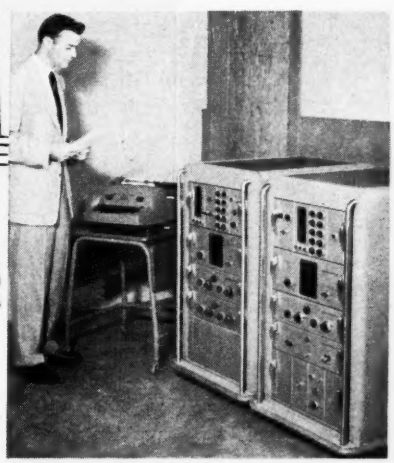
. . . punches a master control tape so that a similar test format can be repeated at any time . . . fully automatically.

. . . provides a punched paper tape for automatic conversion of all bridge outputs to IBM punched cards.

. . . operates with ± 0.1% of full-scale accuracy . . . i.e., resolves d-c inputs greater than ± 1 mv into ± 1000 counts within ± 1 count.

The Data-Processing System designed and built for Lockheed is but one example of the CEC Systems Division's work. For more facts on what CEC Systems Engineering can do for you, write today for Bulletin CEC 1304-X30.





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Electronic Instruments for Measurement and Control

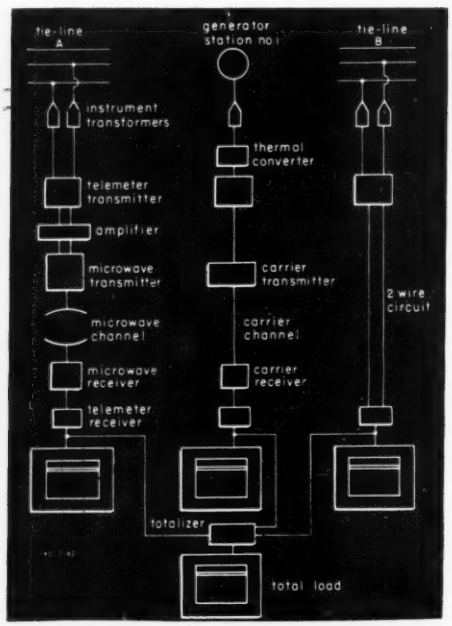
For more information circle **108** on inquiry card.

INSTRUMENTS and AUTOMATION Briefs

For this literature circle number on inquiry card.

Power Generation Instruments

System operators and load dispatchers use various models of the ElectroniK potentiometer for recording and indicating system variables. Since much of the data which they require must be relayed from distant generating stations and interconnections, telemetering equipment is used



to transduce the measured variable to a pulse signal, transmit and receive the signal, and to convert the pulses to an emf that can actuate the recorder.

There are four telemetering systems used with the *ElectroniK* recorders: (1) General Electric Co.'s frequency type and (2) their torque balance type, (3) Metrotype Corporation's system, and (4) Westinghouse Electric Corporation's *Freq-O-Tron* system.

The transmitters for G. E.'s frequency type and Metrotype systems are similar in that both use wattmeters to translate the signal from the measuring element into a shaft speed. The shaft speed in turn is translated into electrical pulses by a photoelectric cell. In the G. E. transmitter, a notched disc rotates between the light source and the cell, while in the Metrotype unit, the rotating disc has black stripes painted on it to set up pulses in the photoelectric cell . . . (*From new 36-page Bulletin* 9070, *"Instruments for Electric Power Generation," Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.*)

For this literature circle **401** on inquiry card.

Industrial Potentiometers

A potentiometer measures an emf of unknown value by comparing it with a known emf. The unknown emf is balanced electrically against the known emf. When the two

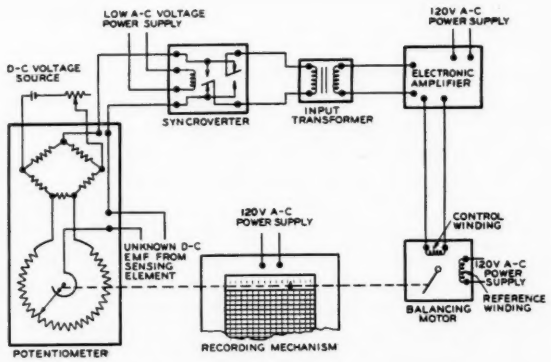


Figure 6. Operating Principle of Dynamaster d-c Potentiometer

Variable	Sensing Element	Type of Dynamaster
TEMPERATURE	Thermocouple ——— p. 36 Radiation Unit ——— p. 37 Resistance Bulb ——— p. 37	d-c potentiometer (pyrometer) d-c potentiometer (millivoltmeter) a-c resistance bridge d-c resistance bridge
FLOW	Turbine-driven magneto ——— p. 49	Frequency converter
PRESSURE	Pressure cells ——— p. 48	a-c resistance bridge (strain)
ABSOLUTE PRESSURE	Thermocouple Type Vacuum Gauge, Ionization Type Gauge ——— p. 49	d-c potentiometer (millivoltmeter)
pH	Glass Electrodes ——— p. 39	d-c potentiometer (millivoltmeter)
SOLUTION CONDUCTIVITY	Conductivity Cell ——— p. 39	a-c conductivity bridge
a-c POWER	Thermal Converters ——— p. 40	d-c potentiometer (millivoltmeter)

emf's are brought to balance, no current flows in the detector circuit. In the Dynamaster Potentiometer, balancing is automatically done by the motor-driven contact on the slidewire.

A change in the condition affecting the sensing elements . . . creates an unbalance condition in the bridge circuit of which the sensing element forms one leg. This a-c voltage unbalance (error-signal) is stepped up by the electronic amplifier to a power level sufficient to energize the control field of the balancing motor and thereby cause rotation in a direction to achieve a rebalance of the bridge—(*From new 62-page Bulletin P1245-A, "Electronic Instruments," The Bristol Co., Waterbury 20, Conn.*)

For this literature circle **402** on inquiry card.

Magnetic Tapes

"Scotch" Brand Magnetic Recording Tapes are offered with three different types of magnetic coatings, each designed to give outstanding performance in a particular range of recording applications. Each has a characteristic color—reddish brown for the standard coating, dark green for the "High Output" (H.O.), and dark red for the thin "Extra Play" coating. The standard coating has found wide acceptance for most general recording uses.

The "High Output" (H.O.) coating offers greater overload protection at long wave lengths while retaining all of the desirable features of the standard coating; the "High Output" coating permits both greater dynamic range and freedom from distortion on signal peaks, and finds wide usage in high fidelity audio recording. The "Extra Play" offers 50% more recording time, best high-

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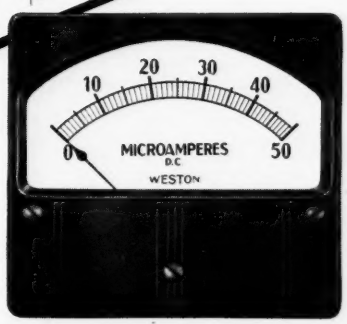

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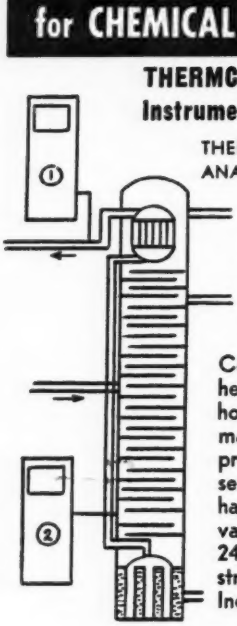

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For more information circle **111** on inquiry card.

BRIEFS—CONTINUED

frequency output and pulse resolution. (*From new 12-page Catalog "Physical and Magnetic Properties of Scotch Magnetic Tape," Minnesota Mining and Manufacturing Co., Saint Paul 6, Minn.*)

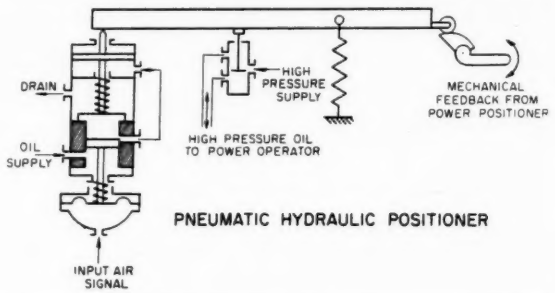
For this literature circle **403** on inquiry card.

Pneumatic-Hydraulic Pilot Positioner

The Hagan Pneumatic Hydraulic Positioner is a component used for converting "open or shut" type hydraulic power units into positioning power operators.

This PowrAmp positioner accepts a pneumatic input signal and operates a hydraulic multi-ported, high pressure spool valve furnishing hydraulic fluid to the power unit. Mechanical motion feedback from the power unit to the positioner insures a definite power unit piston (or vane) position for every pneumatic input signal value.

Accepting 0-30 psig pneumatic input signals, the positioner operates with hydraulic fluid supply pressures



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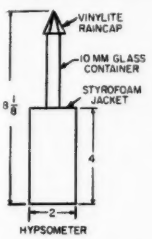
up to 2,000 psig with flow capacities of 18, 54, and 80 gpm available.

Applicable to rotary power units or inline cylinders, the positioner feedback rotation is limited to a maximum of 80 degrees. (Applications have been made to 90 degree valves.) This component insures a positioning accuracy of better than ¼% full stroke. Present models are supplied with linear cam only.

Included with the unit is a potentiometer used for electrically transmitting a signal showing the piston or vane position remotely. (*From new 20-page Bulletin MSP—133, "Control for Aerodynamic Research and Testing Facilities, Hagan Corp., Pittsburgh 30, Pa.*)

For this literature circle **404** on inquiry card.

Hypsometer



In principle, the hypsometer is an instrument which utilizes the vapor pressure vs. temperature characteristics of a liquid in the measurement of ambient pressure. The measurement is made by means of a temperature sensitive element consisting of one or more thermistors which senses the equilibrium temperature of the liquid-vapor phase of the fluid used. Hence, the hypsometer acts as a transducer which converts a pressure measurement to an electrical resistance output.

1. Range: 1600—4 millibars (760—3 mm of hg)
2. Rate of Ascent: 1000—1500 fpm.
3. Lapse Rate of Ambient Temperature: 2°C per minute to −80°C; constant at −80°C thereafter
4. Accuracy: Range (Pressure in mbs.) 1060—450; 450—70; 70-4 Accuracy (% of True Value) ±0.3%; ±0.5%; ±0.7%

(*From new 20-page "Technical Catalog of Veco Prod-*

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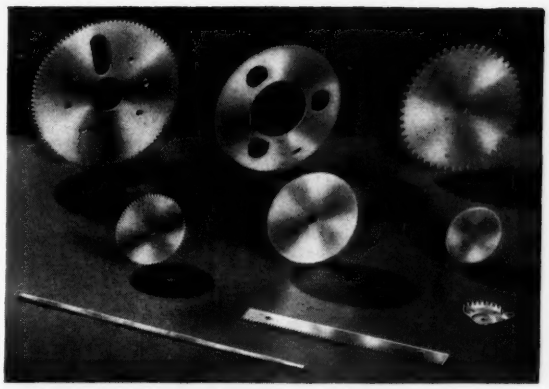

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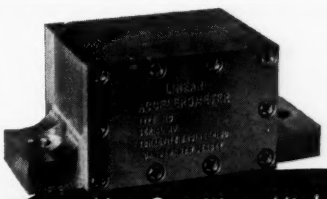

Type HG. This model has its sensitive axis parallel to the mounting base. Type VG has its sensitive axis perpendicular to the mounting base.

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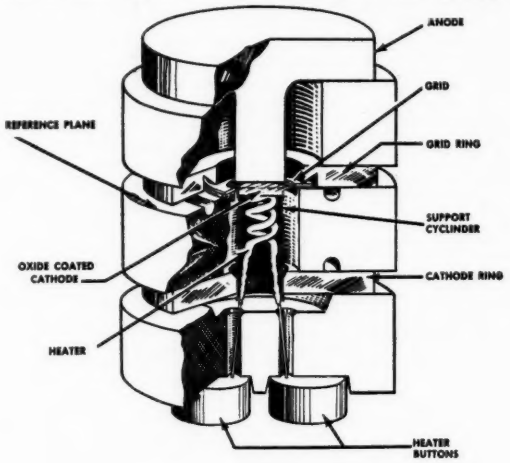
BRIEFS—CONTINUED

ucts,"—Thermistors, Varistors, Gas Analysis Cells, Combustion Analyzers, Biological Instruments, etc.—Sixth Edition, Victory Engineering Corp., Springfield Rd., Union, N. J.)

For this literature circle **405** on inquiry card.

Metal-Ceramic Tubes

Generally, micro-miniature ceramic tubes consist of small ceramic and metal layers arranged alternately. The width of these layers is not indicative of the spacing of



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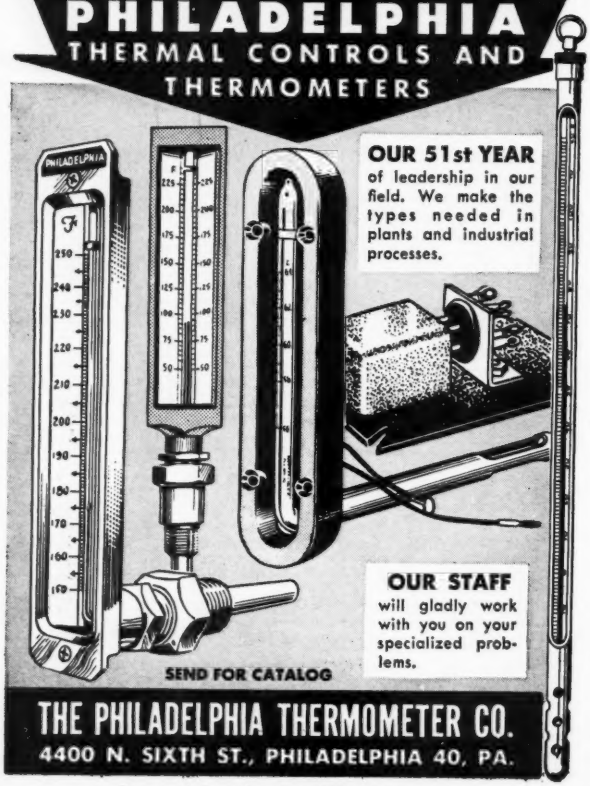

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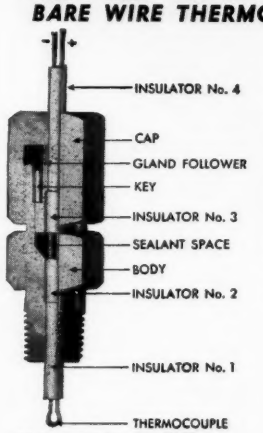

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internal parts, since interelectrode spacings within such tubes are a few thousandths of an inch . . . . Micro-miniature tubes of this general design and construction will withstand operating temperatures in excess of 500 C. Their rigid and compact ceramic construction will resist other environmental factors like impact shock and vibration to a remarkable degree.

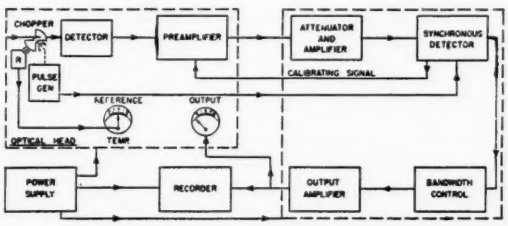
The first G-E micro-miniature ceramic receiving tube-type, 6BY4, is a low-noise, high-mu triode for UHF-VHF television receivers. This type is about $\frac{3}{8}$" long and $\frac{5}{16}$" in diameter. (*From new 20-page Catalog "G-E Micro-miniature Metal-ceramic Receiving Tubes, General Electric Co., Tube Dept., Schenectady 5, N. Y.*)

For this literature circle **406** on inquiry card.

Electro-Optical Instruments

OptiTherm Radiometers (illustration) employ a unique optical chopping principle in which a thermistor detector continuously compares the infrared radiation from the target with the infrared reference black body at a known temperature level.

OptiTherm Infrared Detectors are rugged components for use as sensing elements in radiometers, pyrometers, infrared spectrometers, gas analyzers, product control units or other infrared instruments . . . The blackened thermis-



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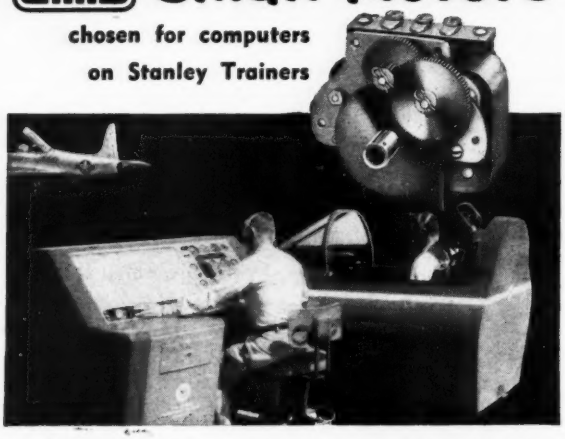

Simulating various systems of an actual jet plane in flight, Stanley Cockpit Procedure Trainers give Air Force student pilots intensive flight training right on the ground. To assure precision operation of fuel computers and indicator transmitters, Stanley Aviation Corporation selected Barber-Colman OYAZ type reversible motors. For accurate actuation of your products, too, there is a wide selection of Barber-Colman motors up to 1/20 hp. Unidirectional, synchronous, and reversible . . . with or without gearing . . . open or enclosed. Write for new Catalog F-4271-6.

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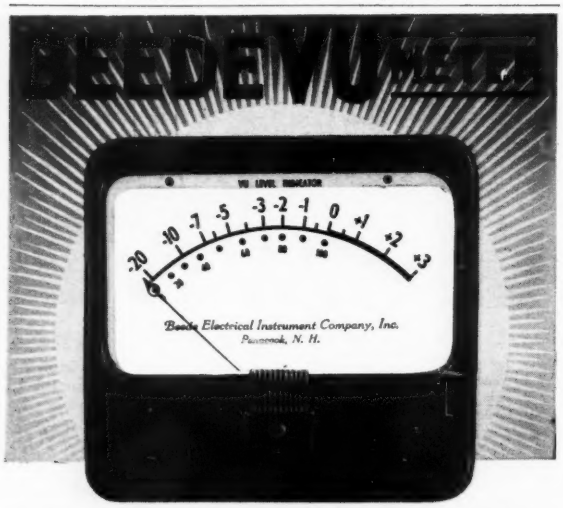

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BRIEFS—CONTINUED

tor element absorbs 80 percent or more of the incident infrared radiation.

The Barnes Industrial *Process Refractometer* continuously measures the difference in refractive index between a flowing liquid sample and a reference liquid. Refractive index is a characteristic physical constant possessed by all liquids and may be measured by observing the bending of a beam of light upon passing a boundary between the liquid to be measured and some reference material.

Sources and components for *infrared systems* include Detector Preamplifier, Reference Sources, and Controllers. Sources includes Laboratory Blackbody (60-230°C), High Temperature Source (200-600°C), Blackbody Point Source (180-430°C) and Extended Field Source 12″ x 12″ (0-250°C). (*From new 8-page pamphlet "Electro-Optical Instruments for Process Control," Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.*)

For this literature circle **407** on inquiry card.

Controlled Closing Air Valve (CCAV)

Water hammer is the concussion resulting when a moving column of water is suddenly arrested. Two types of flow conditions are pertinent:

1. Steady state operation, where both the head or line pressure and the flow rate are constant. This can be called "normal condition."

2. Transient operation, where conditions are changing rapidly due to any cause. The effect of valve operation, the characteristics of the pumps, the length, size and material of the pipe as well as the velocity of flow will all have a bearing upon the magnitude of the surge and the rate of change of pressure . . . When water hammer occurs, the intensity and rapidity of its action is capable of rup-

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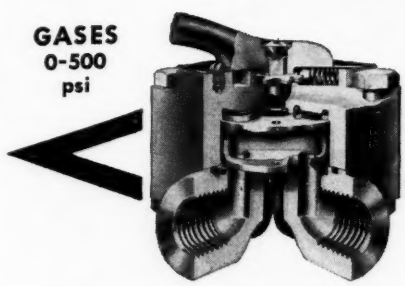

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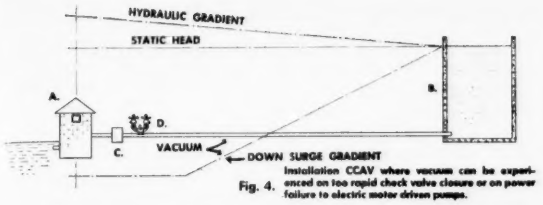

Fig. 4. Installation CCAV where vacuum can be experienced on too rapid check valve closure or on power failure to electric motor driven pumps.

A. Pumping Unit. B. Reservoir. C. Check Valve. D. CCAV Cluster.

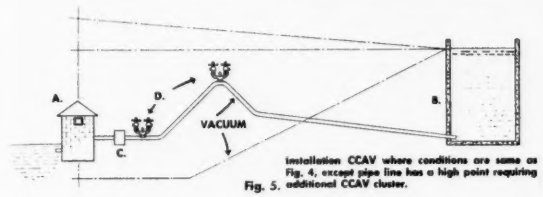

Fig. 5. Installation CCAV where conditions are same as Fig. 4, except pipe line has a high point requiring additional CCAV cluster.

turing the pipe line, fittings or valves, with attendant further damage from washout. Such occurrences are prone to happen when line valves are closed too rapidly, or upon failure of a pump to continue operating. The source of the occurrence is where a vacuum may follow a parting of the water column.

The CCAV valve, by virtue of its combined function of an air inlet (vacuum breaking) valve with its controlled closing features (when the line is being filled), provides a means of protection that will, upon proper location and sizing, prevent the danger of pipe rupture. . . . The quick-opening, controlled closing air valve relieves the vacuum, lengthens the pressure reversal time and reduces the total head effective on the upper column to accelerate it backwards. (*From new 12-page Bulletin 200, Simplex Valve and Meter Co., Lancaster, Pa.*)

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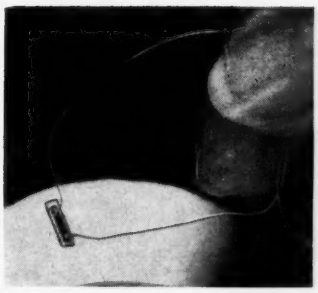

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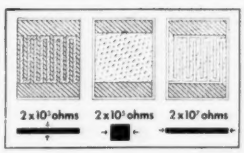

For a booklet giving detailed information on Kodak Ektron Detectors, write Military and Special Products Sales,

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Kodak

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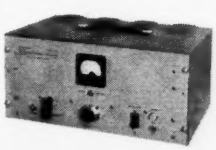
research-quality DC



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Stability	less than 5 mv/hr drift
Voltage Regulation	0.1%
Ripple	less than 1 mv peak-to-peak

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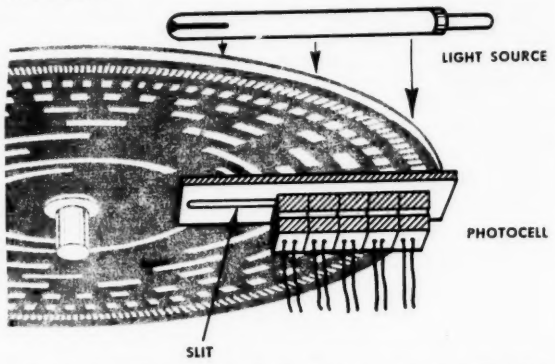
Angular Position Encoders

13-digit and 16-digit optical encoders generate binary-parallel code signals representing angular shaft position with accuracies of ±½ part in 8192 (13-digit) and 65536 (16-digit).

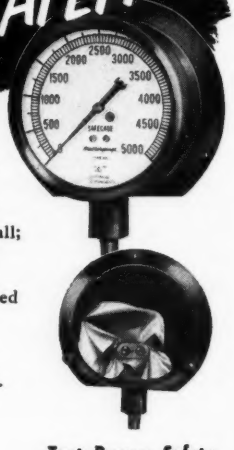


The major components of the Baldwin Angular Position Encoder are (1) a glass disk, mounted on a shaft and covered on one side with a code pattern of transparent and opaque areas, arranged in concentric tracks; (2) a pulsed light source; (3) a reading slit; (4) a bank of photocells, one for scanning each track on the code disk.

The disk, as it revolves, switches on and off illumination from the lamp directed at the individual photocells. Photocells behind a transparent area of the disk, receiving light, transmit a pulse corresponding to the binary digit one. Binary zero is represented by the absence of pulse from photocells behind an opaque area, which do not receive light. (*From new 8-page Bulletin No.* 0156, *The Baldwin Piano Co., Electronics Div.,* 1801 *Gilbert Ave., Cincinnati 2, Ohio.*)

For this literature circle **409** on inquiry card.

New advance in... GAUGE SAFETY



Another Marsh development... new "SAFE-CASE" gauge for those conditions where over-pressures of explosive force can occur.

Face well protected by solid metal wall; but, still more important, *entire back* is thin metal plate that opens out to exhaust any abnormal pressure.
In testing, heavy blank cartridges, fired within back of case, did not even break crystal.

Use "Safecase" for your toughest services. It is standard in Marsh "Mastergauge"—the highest development in pressure gauges.
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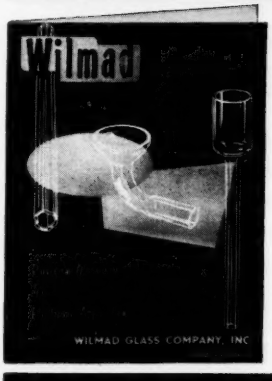

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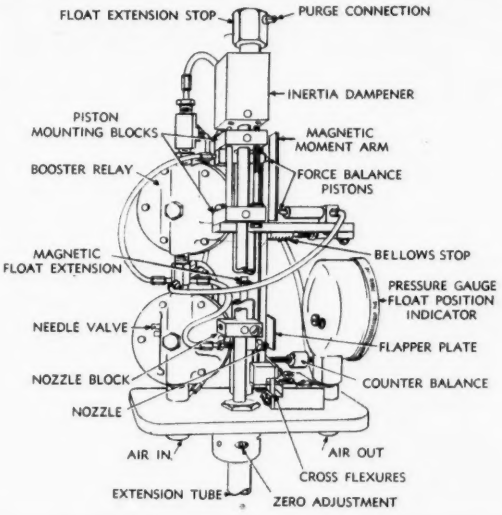

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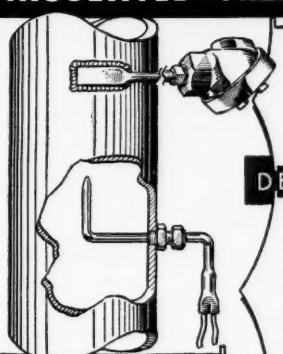

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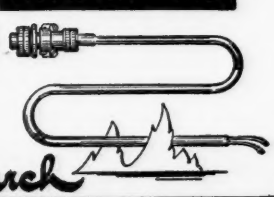

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The RESISTANCE BRIDGE system employs a modified resistance measuring Wheatstone bridge and is designed for use with The Foxboro Dynalog and the ATC Atcotran Receivers . . . A differential transformer coil is used.

The DC SIGNAL system also uses a differential transformer . . . the AC signal is converted to a 20 millivolt DC signal which may then be used with most DC potentiometers including Leeds & Northrup, Bristol, General Electric and Fielden. (*From new 12-page Bulletin 130, Brooks Rotameter Co., Lansdale, Pa.*)

For this literature circle **410** on inquiry card.

pH and Conductivity

In order to avoid the use of negative numbers and fractions, a scale was set up under the definition $pH = -\log_{10}(H^+)$; or, the pH value is numerically equivalent to the logarithm of the hydrogen-ion concentration, with

TABLE 2-1—pH SCALE

H^+ Ion Concentration		pH	
10.0	10^{+1}	−1	Strong acid
1.0	10^{0}	0	↑
0.1	10^{-1}	1	
0.01	10^{-2}	2	
0.001	10^{-3}	3	Increasing acidity
0.0001	10^{-4}	4	
0.000,01	10^{-5}	5	
0.000,001	10^{-6}	6	
0.000,000,1	10^{-7}	7	Neutral
0.000,000,01	10^{-8}	8	
0.000,000,001	10^{-9}	9	
0.000,000,000,1	10^{-10}	10	
0.000,000,000,01	10^{-11}	11	Increasing alkalinity
0.000,000,000,001	10^{-12}	12	
0.000,000,000,000,1	10^{-13}	13	↓
0.000,000,000,000,01	10^{-14}	14	Strong base

$[OH^-]$ ion concentration can be determined by the formula: $[H^+]\,[OH^-] = 10^{-14}$

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(REDUCED INSPECTION QUALITY ASSURANCE PLAN)

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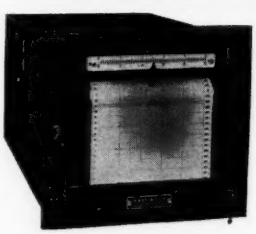

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For more information circle **136** on inquiry card.

the minus sign changed to plus. The pH of pure water at 25 C is thus 7, since there are 10^{-7} moles of hydrogen ions in a liter of pure water, and $\log_{10}10^{-7}$ equals -7.

Like pH, the measurement of oxidation-reduction potential (Redox) is concerned with ions in solution. These ions, all electrically charged, have either an excess or a deficiency of electrons, and are termed, respectively, negative or positive ions. Oxidation-reduction reactions are characterized by a transfer of electrons between the reactants.

All ions in solution affect conductivity, whereas pH and Redox measurements are based on properties of certain specific ions only.

Oxidation involves the loss of an electron (s), or an increase in positive electrical charge, and does not necessarily require the presence of oxygen. Reduction involves the gain of an electron (s) or a decrease in positive charge.

If a suitable electrode (usually platinum or gold) is immersed in a solution, it reaches an electrical potential which depends upon the relative concentrations of oxidized and reduced ions. The potential developed represents the equilibrium between the tendency of oxidized ions to acquire an electron from the metal electrode (and thereby become reduced) and the tendency of the reduced ions to release an electron to the electrode.

As in pH measurement, a reference electrode must be added to complete the electrical circuit. The calomel electrode is often used, but other electrodes are also employed for special purposes.

The electrode potential in oxidation-reduction potential measurement can be measured in essentially the same manner as the potential of pH electrodes. Normally, the instruments are identical except for calibration. Redox instruments are usually calibrated in terms of millivolts; pH instruments are calibrated directly in pH units. (*From new 20-page Catalog 1551, "pH and Conductivity," Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.*)

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G-V Write for Pub. No. 35 — engineering data and drawings
G-V CONTROLS INC.
38 HOLLYWOOD PLAZA, EAST ORANGE, NEW JERSEY

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INSTRUMENTS and AUTOMATION — New Literature

AUTOMATION

"Tel-O-Set" Transmitter. New 4-page Specification Sheet 1003-1 describes maker's "Tel-O-Set" transmitter for measuring and transmitting temperature, gage pressure or absolute pressure.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **412** on inquiry card

Aerodynamic Testing Controls. New 20-page Bulletin MSP-133 describes maker's line of electrical and electronic automatic control equipment for surge, altitude and mass flow in subsonic, transonic and supersonic wind tunnels.—Hagan Corp., 323 Fourth Ave., Pgh. 30, Pa.

Circle **413** on inquiry card

Sheet Control Systems. New 8-page Bulletin B-1456 describes maker's area-weight control systems for the rubber and plastics industries.—Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio.

Circle **414** on inquiry card.

Photoelectric Alarms, Controls. New 36-page Brochure illustrates applications of photocell sets for actuating counters, burglar and smoke alarms, lighting systems, and providing information in automatic production and conveying systems.—Worner Electronic Devices, Box 10, Rankin, Ill.

Circle **415** on inquiry card.

Automatic Rudder Control. New 12-page Bulletin reprints article describing use of maker's automatic rudder control "Dart".—New 8-page Bulletin presents specs on DART I unit aircraft.—Air Associates, Inc., Teterboro, N. J.

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Hydraulic Controllers. New 16-page Bulletin 305 describes application of maker's jet-pipe regulators for automatic control in the glass industry.—Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.

Circle **417** on inquiry card.

Limit Controller. New 4-page Bulletin MRM240 describes maker's "Series 135R" relay for high-limit action and "Series 135R-RO" relay for low-limit action in switching, control circuits.—Manning, Maxwell & Moore, Inc., Industrial Controls Div., Stratford, Conn.

Circle **418** on inquiry card.

Current Controller. New 4-page Specification Sheet GE-500 describes and illustrates maker's Alternating Current Controller—an electro-pneumatic converter for control of alternating current motors and power circuits.—Hagan Corp., Pittsburgh 30, Pa.

Circle **419** on inquiry card.

Servo-Kit. New 4-page Brochure presents "Servo-Kit" containing components and training course for experimentation and demonstration of servomechanism controls.—Servo Systems Co., 55 Meeker Ave., Newark 12, N. J.

Circle **420** on inquiry card.

Micro Positioners. Inductosyn Machine Tool Control. New 12-page Bulletin 819 describes maker's linear and angular micro positioning systems for automatic control of machine tools, precision positioning, etc.—Farrand Controls, Inc., 4401 Bronx Blvd., New York 70, N. Y.

Circle **421** on inquiry card.

Welding Control. New 6-page Bulletin 338 presents maker's predetermined, electronic-counter that counts cycles of power line frequency to control welder sequence.—Sciaky Bros., Inc., 4915 W. 67 St., Chicago 38, Ill.

Circle **422** on inquiry card.

VALVES

Air Control Valves. New 44-page Catalog 54 SV describes maker's solenoid-operated 2-, 3-, and 4-way air control valves; also direct and pilot operated valves and parts.—Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.

Circle **423** on inquiry card.

Valves. New 4-page Bulletin 65 describes maker's "Series S" "Krebs" pinch-type valves.—Equipment Engineers, Inc., 41 Sutter St., San Francisco 4, Calif.

Circle **424** on inquiry card.

Solenoid Valves. New 36-page Catalog 201 presents engineering data, flow charts, prices, selection chart, etc., for maker's line of 2-, 3-, and 4-way solenoid valves and accessories.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **425** on inquiry card.

Cylinder Valve Actuators. New 2-page Bulletin 3022 presents maker's "Quad" actuators built to operate high-pressure plug and ball valves up to 36" size.—Ledeen Mfg. Co., 1600 S. San Pedro St., Los Angeles 15, Calif.

Circle **426** on inquiry card.

Valves. New 2-page Bulletin BV-1 presents maker's line of hand, foot, or solenoid operated valves for air or oil service up to 200 psi.—Modernair Corp., 400 Preda St., San Leandro, Calif.

Circle **427** on inquiry card.

MOTORS, SERVOS

Torque Motor, Servovalves. Four new 4- and 8-page bulletins describe and illustrate maker's Models 3, 4 and 7 hydraulic servovalves, and Model 9 torque motor.—Midwestern Instruments, P.O. Box 7186, Tulsa, Oklahoma.

Circle **428** on inquiry card.

Servo Motors. New 16-page Catalog 7 presents characteristics charts and specs for maker's large line of servo motors and generators.—G-M Laboratories Inc., 4300 N. Knox Ave., Chicago 41, Ill.

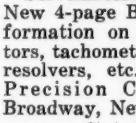
Circle **429** on inquiry card.

Servomotors, Servomechanisms. New 4-page Bulletin 376 presents information on maker's induction motors, tachometer generators, synchros, resolvers, etc.—Norden-Ketay Corp., Precision Components Div., 555 Broadway, New York 12, N. Y.

Circle **430** on inquiry card.

Servomotors, Synchros, Resolvers. New 4-page Bulletin 374 presents specs on maker's line of 36 synchro resolvers for data transmission.—New 2-page Bulletin 371 presents maker's gear head servo motors.—New 4-page Bulletin 382 presents diagrams for maker's 60 cycle and 400 cycle magnetic servo amplifiers.—Norden-Ketay Corp., 99 Park Ave., New York, N. Y.

Circle **431** on inquiry card.



TEMPERATURE

Thermocouples. New 44-page Catalog F-5228-3 illustrates and describes maker's line of thermocouples, protecting tubes, accessories, etc.—Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.

Circle **432** on inquiry card.

Thermometers. New 4-page Bulletin 148 presents specs for maker's new bimetal dial thermometers with swivel joint to allow readings from any angle.—Manning, Maxwell & Moore, Inc., Stratford, Conn,

Circle **433** on inquiry card.

Thermocouple Accessories. New 4-page Bulletin 1610-A describes maker's thermocouple accessories, including adapters, resistors, terminals, and connectors.—Revere Corp. of America, Wallingford, Conn.

Circle **434** on inquiry card.

Temperature Regulator. New 4-page Bulletin 500 describes maker's self-operating temperature regulator Series V.—A. W. Cash Co., P. O. Box 551, Decatur, Ill.

Circle **435** on inquiry card.

Sealed Thermostats. New 8-page Bulletin 3009 B presents specs and mounts for maker's sealed-in-glass thermostats.—Thomas A. Edison, Inc., Instrument Div., W. Orange, N. J.

Circle **436** on inquiry card.

TC Assemblies. New 28-page Catalog 1556 describes and tabulates maker's thermocouple assemblies and pressure sealing glands.—Conax Corp., 7311 Sheridan Dr., Buffalo 21, N. Y.

Circle **437** on inquiry card.

Thermocouple. New 4-page Bulletin presents data of maker's patented thermocouple for high temperatures with high resistance to oxidation and improved emf stability in reducing atmospheres.—Driver-Harris Co., Harrison, N. J.

Circle **438** on inquiry card.

Temperature Cabinets. New 2-page Bulletin 61 presents maker's sub-zero temperature cabinets for testing of electronic components, and cold treatment of metals and fittings.—Webber Engineering Corp., Dept. SZ-469, P.O. Box 217, Indianapolis, Ind.

Circle **439** on inquiry card.

Thermometers, Thermostats. New 12-page Catalog 55 presents maker's glass-tube thermometers and thermostats.—Reliable Instrument Co., 505 N. Eighth St., Philadelphia 23, Pa.

Circle **440** on inquiry card.

Thermostats. New 4-page Bulletin presents maker's "Temp-Guard" thermostats—hermetically sealed units that respond to current as well as heat.—The Franklin Dales Co., 180-184 E. Mill St., Akron 8, Ohio.

Circle **441** on inquiry card.

Miniature Thermocouple Head. New 2-page Bulletin 356-3M-R presents maker's new miniature thermocouple connection head for operating temperatures up to 500°F.—The Marlin Mfg. Corp., 12410 Triskett Rd., Cleveland 11, Ohio.

Circle **442** on inquiry card.

Thermistor, Thermometers. New 2-page Data Sheet describes twelve-channel indicating thermometer with battery power and thermistor probes.—Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill.

Circle **443** on inquiry card.

Thermocouple Restorer. New 2-page Leaflet describes installation of maker's "Restorer", a thermocouple circuit monitor.—The Peerless Electric Co., 1455 W. Market St., Warren, Ohio.

Circle **444** on inquiry card.

Temperature Controller. New 4-page Specification Sheet S1010-1 describes "Model 077" nonindicating electronic temperature controller.—Minneapolis-Honeywell Regulator Co., Ind. Div., Phila. 44, Pa.

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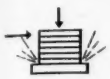
NEW LITERATURE



PRESSURE, WEIGHT

Pressure Ratio Computer. New 4-page Bulletin MSP-103B describes and illustrates maker's "Model PR-O" pressure-ratio computer capable of square-root extraction, squaring and multiplying and dividing operations for compressor, exhaustor or blower control.—Hagan Corp., Pittsburgh 30, Pa.

Circle **446** on inquiry card.

Bulk Scale. New 4-page Bulletin 4049A describes maker's automatic bulk grain shipping scale for weighing free-flowing grains.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.

Circle **447** on inquiry card.

FLOW

Volumetric Flow Meter. New 8-page Bulletin 301 presents illustrations and applications of maker's "Transometer," a positive displacement type flowmeter and pneumatic signal transmitter for metering fuel oil, viscous fluids, etc.—Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.

Circle **448** on inquiry card.

Flow Computer. New 4-page Bulletin, Cat. No. 310398, presents maker's new pressure-compensated, totalizing flow computer for orifice measurement of fluids.—Librascope, Inc., 808 Western Ave., Glendale, Calif.

Circle **449** on inquiry card.

Flow Tube. New 6-page Bulletin FT describes maker's Gentile flow tube, used as primary element for metering of gases and liquids.—Foster Engineering Co., 835 Lehigh Ave., Union N. J.

Circle **450** on inquiry card.

Centrifugal Pump. New 4-page Bulletin 1060 presents specs for maker's canned-motor axial flow pump that mounts directly in pipeline and gives heads to 20 ft with capacities to 22 gpm.—Chempump Corp., Station N, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Circle **451** on inquiry card.

Flowmeters, Vacuum Gages. New 4-page Catalog 136 presents maker's line of instruments, incl. air-velocity-meters, flowmeters, vacuum gages, standard cells, etc.—Hastings-Raydist, Inc., Newcomb Ave., Hampton, Va.

Circle **452** on inquiry card.

Flow Indicator. New 2-page Bulletin presents specs and dimensions for maker's armored flow indicator for purge service or flow rate indication at elevated pressures. New 8-page Bulletin 140 describes maker's rotameter kits for research, laboratory, pilot plant and field, with interchangeable metering elements.—Brooks Rotameter Co., Lansdale, Pa.

Circle **453** on inquiry card.

MOISTURE

Moisture Testing. New 4-page Data Sheet 11259B describes maker's "Aquatrator" for moisture determinations in liquid or solid chemicals, foods, drugs and industrial products.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **454** on inquiry card.

Water Deaeration. New 4-page Publication 4650 describes principles of operation, and applications of deaeration in boiler feed and process water.—Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia 32, Pa.

Circle **455** on inquiry card.

AIR

Air Dryers. New 2-page Data Sheet 5561 presents flow diagrams and specs for maker's desiccant-type atmospheric regeneration dryers.—Industrol Corp., 472 Westfield Ave. East, Roselle Park, N. J.

Circle **456** on inquiry card.

Air Pump. New 2-page Product Data Sheet 2-29A describes maker's oil-free air pumps for missile pressurizing or compressed air applications in aircraft electronic installations.—Lear-Romec Div., Lear, Inc., Elyria, Ohio.

Circle **457** on inquiry card.

High-Pressure Air. New 1-page Bulletin AC-15 presents mobile high-pressure (5000 psi) air stand for leakage testing and calibrating instruments. New 1-page Bulletin AC-13 presents high-pressure (3600 psi) bottle cart with 18000 cu in capacity.—Accessory Controls & Equipment Corp., 146 Willard Ave., Newington, Conn.

Circle **458** on inquiry card.

Air Filters. New 2-page Bulletin C-22A presents specs on maker's line of instrument air filters and driers.—The Briggs Filtration Co., River Road, Washington 16, D. C.

Circle **459** on inquiry card.

VIBRATION

Vibration Monitors. New 4-page Bulletin 500-1A describes maker's vibration monitors and malfunction detectors for protection of rotating equipment.—The Beta Corp., P. O. Box 8625, Richmond 26, Va.

Circle **460** on inquiry card.

Shock Mountings. New 8-page Bulletin 1000 presents maker's line of mountings for shock and vibration control.—Robinson Aviation Inc., Teterboro, N. J.

Circle **461** on inquiry card.

Vibration Switch. New 6-page bulletin presents specifications and drawings of maker's multi-channel "Vibraswitch" for protection of rotating equipment against excessive vibration.—The Beta Corp., Forest Ave. at Ridge Rd., Richmond 26, Va.

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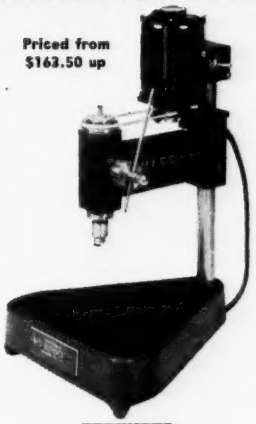

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Universal 115 volt motor.
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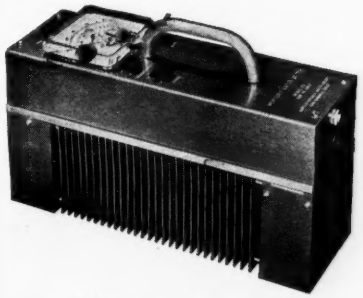

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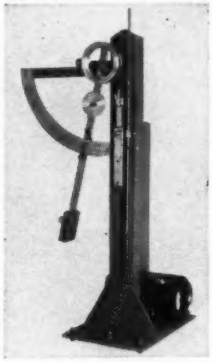

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NEW LITERATURE

TIME, SPEED

Timers, Recorders. New 2-page Bulletin MG-56 presents maker's multi-range timers and lists prices.—New 2-page Bulletin presents maker's interval timer with ten ranges.—New 2-page Bulletin presents portable 36-line stylus operations recorder available with rotations once per second to once a year.—Gorrell & Gorrell, Haworth, N. J.

Circle **463** on inquiry card.

Technical Watches. New 4-page catalog presents 17 technical watches to serve a variety of timing purposes.—Longines-Wittnauer Watch Co., Inc., 580 Fifth Ave., New York 36, N. Y.

Circle **464** on inquiry card.

Time Measurement. New 8-page Bulletin presents maker's instrument combining a marker generator and pulse generator for accurate lab and production time-measurement.—Brubaker Electronics, Inc., 3652 Eastham Drive, Culver City, Calif.

Circle **465** on inquiry card.

Wide-Range Tachometer. New Leaflet describes use of maker's wide-range tachometer with multiple take-off heads, in a system that provides central control of a 10-bin mixing unit.—Metron Instrument Co., 432 Lincoln St., Denver 3, Colorado.

Circle **466** on inquiry card.

Tachometer Generators. New 4-page Bulletin F-4344-3 presents characteristics for maker's permanent magnet tachometer generators capable of supplying 40 v per 1000 rpm within ± 0.5% linearity over the operating range.—Aircraft Controls Div., Barber-Colman Co., 1400 Rock St., Rockford, Ill.

Circle **467** on inquiry card.

TESTING, GAGING

Plug Gages. New 4-page Bulletin 595 presents maker's go-no-go reversible plug gages.—Pratt & Whitney Co. Inc., Charter Oak Blvd., W. Hartford, Conn.

Circle **468** on inquiry card.

Paper Testers, Scales. New 20-page Brochure describes cordage scales, thickness gages, strength testers, Mullen testers, etc.; also indicating and recording tachometers.—Amthor Testing Instrument Co., Inc., 45-53 Van Sinderen Ave., Brooklyn 7, N. Y.

Circle **469** on inquiry card.

Indicator Gages. New 2-page Bulletin illustrates maker's universal test indicators with interchangeable contact points and shockproof movement.—George Scherr Co., Inc., 200 Lafayette St., New York 13, N. Y.

Circle **470** on inquiry card.

Fineness Tester. New 2-page Bulletin 233 describes maker's air-permeability tester for fineness of cement, pharmaceutical powders and other granular materials.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **471** on inquiry card.

Air Gage. New 32-page Catalog 56D describes maker's "Dimensionair" air gage for comparing work piece dimensions.—Federal Products Corp., 1144 Eddy St., Providence 1, R. I.

Circle **472** on inquiry card.

Spacing Comparator. New Leaflet presents maker's portable spacing comparator and accessories.—Jerpbak Bayless Co., Solon Road, Solon, Ohio.

Circle **473** on inquiry card.

Nondestructive Testing. New 8-page Bulletin 148-2 reviews nondestructive testing systems and illustrates "Magnaflux" inspection for early crack detection in raw stock, castings, etc.—Magnaflux Corp., 7300 West Lawrence Ave., Chicago 31, Ill.

Circle **474** on inquiry card.

SMOKE, COMBUSTION

Combustion Test Kit. New 4-page Bulletin G-20 presents maker's combustion test kit for CO_2 content, draft, stack temperature, and smoke in gas, oil or coal fired installations.—F. W. Dwyer Mfg. Co., Dept. IAP, P.O. Box 373, Michigan City, Ind.

Circle **475** on inquiry card.

Smoke Indicator. New 4-page Bulletin CM-22 describes maker's smoke density indicators and recorders for single and multiple stacks.—Electronics Corp. of America, Dept. CN-4, 718 Beacon St., Boston 15, Mass.

Circle **476** on inquiry card.

Smoke Alarms. New 1-page Bulletins 106-F & 107-F describe maker's photoelectric smoke density alarms for excessive smoke in flues.—Reliance Instrument Mfg. Corp., 190 Glen Cove Ave., Glen Cove, L. I., N. Y.

Circle **477** on inquiry card.

COMPUTERS

Computing Amplifiers. New 32-page booklet is "Applications Manual for GAP/R K2 Series Octal Plug-in Computing Amplifiers."—George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass.

Circle **478** on inquiry card.

Magnetic Heads. New 2-page bulletin presents maker's single-track, read and record magnetic heads designed for digital computers.—Data Storage Devices Div., J. B. Rea Co., Inc., 1723 Cloverfield Blvd., Santa Monica, Calif.

Circle **479** on inquiry card.

Analog Computers. New 16-page Catalog presents maker's "Electronic Analog Computers" and components.—George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass.

Circle **480** on inquiry card.

Analog Computers. New 8-page Data File 121 is article "Introduction to the Basic Theory and Practice of Analog Computers."—Berkeley Div., Beckman Instruments, Inc., Dept. 3441, 2200 Wright Ave., Richmond 3, Calif.

Circle **481** on inquiry card.

NUCLEONICS

Thermopile Detector. New 2-page Specification Sheet presents maker's neutron thermopile, a differential type detector for the measurement of high-level, slow neutrons.—Nuclear Instrument and Chemical Corp., 223 W. Erie St., Chicago 10, Ill.

Circle **482** on inquiry card.

Scintillation Detectors. New 8-page issue of "The Nucleus (No. 11, May '56) describes applications of maker's "Model DS-5" scintillation detectors for operation with scalers, ratemeters, or gamma ray spectrometer systems.—Nuclear Instrument and Chemical Corp., 231 West Erie St., Chicago 10, Ill.

Circle **483** on inquiry card.

RECORDERS

Magnetic Tape Recorders. New 4-page Bulletin presents 21 models of maker's variable and fixed-speed continuous-loop magnetic tape recorders available in single or dual speeds and single, dual and triple channels.—Amplifier Corp. of America, 398 Broadway, New York 13, N. Y.

Circle **484** on inquiry card.

Magnetic Tape. New 4-page Bulletin 32 reviews mechanical considerations in the use of thin-base recording tapes.—Minnesota Mining & Mfg. Co., St. Paul 6, Minn.

Circle **485** on inquiry card.

Oscillographs, Bridge Balance Units. Set of ten new 4- and 8-page bulletins presents maker's multiple channel recording oscillographs, synchro-type data repeater, "Model GA-1R" amplifier, "Model 350" current source, and "Models 430 and 435" bridge balance units.—Midwestern Instruments, P.O. Box 7186, Tulsa, Oklahoma.

Circle **486** on inquiry card.

MAGNETICS

Magnetic Measurements. New 4-page Bulletin C-11 presents maker's control system for stabilization and control of electromagnetic fields in mass spectrometers, cyclotrons, etc. New 4-page Bulletin M-21 describes maker's gaussmeter.—Nuclear Magnetics Corp., 154 Boylston St., Boston 16, Mass.

Circle **487** on inquiry card.

ANALYTICAL, LABORATORY

Infrared Spectroscopy. New set of 4- and 8-page reprints cover introduction to Infrared Spectroscopy, Spectra-Structure Correlations, Analysis of Hydrocarbons, etc. Also includes Bulletin 472-A on "IR-4" infrared spectrophotometer.—Scientific Instruments Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

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5000 MICROSECOND DELAY LINES

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● LONG DELAY ● EXCELLENT PHASE LINEARITY
● LOW ATTENUATION ● TAP SPACING UNIFORMITY

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They feature extremely long delay (which may be extended by cascading several units), low attenuation and excellent phase linearity over a wide range of frequencies. Design is based on M-derived techniques and employs very high Q toroidal inductance assemblies and ultra-stable capacitors.

SPECIFICATIONS

Overall delay	5000 μs±1%
Characteristic Impedance	510 ohms*
Number of Taps	125
Delay between Taps	40.0 μs±1%
Attenuation including insertion loss	better than 3 db at 4kc, 6 db at 7kc
Cutoff Frequency	9.5kc
Phase Linearity	±0.2% up to 6kc, ±1% up to 8kc
Size	19"x5¼"x9" Rack Mount

*Also available with 470; 600 and 1000 ohm impedance.

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NEW CONCEPT... ADVANCED DESIGN IN THERMAL TIME DELAY RELAYS

Designed for high performance and long life, the Curtiss-Wright "SNAPPER" Thermal Time Delay Relay is proving itself in countless applications involving time delay in electrical circuits. Such applications include circuits to provide definite on-off time intervals to delay the application of high voltage until after warm-up period and for over and under voltage protection with simultaneous fault indication.

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to 120 seconds. They are available in metal envelope, miniature (7 and 9 pin) or octal (8 pin) and in a glass envelope in 9 pin only.

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NEW LITERATURE

Balances and Weights. New 24-page Bulletin 15D describes maker's analytical, laboratory, triple beam, heavy duty, industrial, and spring balances and weights for laboratory and industry.— Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill.

Circle **489** on inquiry card.

Refractometer. New 8-page Brochure 25C presents maker's continuous-measurement differential refractometer.—Barnes Engineering Co., Stamford, Conn.

Circle **490** on inquiry card.

pH Measurement. New 4-page Bulletin 911 describes maker's research model pH meter with sensitivity of 0.005 pH.—New 8-page Bulletin 91[illegible] describes maker's line of pH electrodes, including a selection chart.—Cambridge Instrument Co., Inc., 373[illegible] Grand Central Terminal, New York 17, N. Y.

Circle **491** on inquiry card.

Chromatography. New 4-page Bulletin 15-18 presents equipment for paperelectrophoresis available from distribution and new 2-page Bulletin 19-20 presents "Elphorecorder" an automatic scanner and integrator for paperelectropherograms.—New 2-page Bulletin 23/24 describes the "Chromatopart", an automatic fraction collector with photoelectric control.—C. A. Brinkmann & Co., 378 Great Neck Rd., Great Neck, L. I., N. Y.

Circle **492** on inquiry card.

Analytical Balances. New 4-page Bulletin 3-6 describes Sartorius analytical projection balances available from distributor. New 2-page Bulletin A.S.T. 3000 describes speed balance for determination of specific gravity of solids.—New 2-page Bulletin 15/16 presents a balance table for elimination of vibration and shocks.—C. A. Brinkmann & Co., 378 Great Neck Rd., Great Neck, L. I., N. Y.

Circle **493** on inquiry card.

Laboratory Equipment. New 4-page bulletin presents maker's drapemeter, cutter grinder, microtome, polishing machine, laboratory lights, engravers, coaxial wavemeters, etc.—Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.

Circle **494** on inquiry card.

Analytical Instruments. New 2-page Bulletin 11/12 presents a "Coulometer" for volumetric analysis by electrolysis. Available from distributor.—New 2-page Bulletin 9/10 describes research pH meters—New 1-page Bulletin 30 describes line-operated "Polarecord" for recording current and voltages in polarography and amperometric titrations.—New 1-page Bulletin 25 describes electrically-heated sample vacuum-drying apparatus.—C. A. Brinkmann & Co., 378 Great Neck Rd., Great Neck, L. I., N. Y.

Circle **495** on inquiry card.

Gas Analyzers. New 4-page Data Sheet 10.15-8a describes Davis' thermal-conductivity-type gas analyzers with Brown ElectroniK recorders and controllers. — Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **496** on inquiry card.

Laboratory Burners. New 16-page Bulletin 20 presents laboratory burners and attachments.—Central Scientific Co., 1700 Irving Park Road, Chicago, Ill.

Circle **497** on inquiry card.

Laboratory Stirrer, Flash Tester. New 2-page Bulletin 738 describes maker's "Slo-Speed" stirrer for use in flash point tests and laboratory applications; 2-page Bulletin 737 presents "Pensky-Martens" flash point tester.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **498** on inquiry card.

Recoding Spectrophotometer. New 8-page Bulletin GEC-307B presents maker's recording spectrophotometer. Includes extensive bibliography on spectrophotometry..—General Electric Co., Schenectady 5, N. Y.

Circle **499** on inquiry card.

Automatic Distillation. New 8-page Bulletin 730 describes maker's apparatus for automatic distillation between 90 and 700°F with automatic recording of temperature, volume and time.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **500** on inquiry card.

Hydrogen and Carbon Analyzer. New 8-page brochure describes maker's instrument utilizing a hi-frequency combustion furnace for determination of hydrogen and carbon in titanium, zirconium. iron and steel.—National Spectrographic Labs., Inc., 6300 Euclid Ave., Cleveland 3, Ohio.

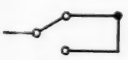
Circle **501** on inquiry card.

Electron Microscope. New 24-page Bulletin SH 3674 (in German) presents thorough discussion of the principles of electron microscopy, and applications of electron microscope.—Siemens & Halske, Siemens New York Inc., 350 Fifth Ave., New York 1, N. Y.

Circle **502** on inquiry card.

Infrared Analyzer. Two new 2-page Specification Sheets 450 and 475 describe Liston-Becker's "Models 21 and 15A" infrared analyzers.—Beckman Instruments, Inc., Fullerton, Calif.

Circle **503** on inquiry card.



SWITCHES, RELAYS

Relays. New 4-page Bulletin R-29 gives description, price and applications of maker's "Amrecon" relays.—Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill.

Circle **504** on inquiry card.

Switches. New 4-page issue of Micro Tips" (Vol. 1, No. 20) presents applications of maker's snap-action switches.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **505** on inquiry card.

Relays. New 24-page Catalog 1956-C7 tabulates characteristics and prices of distributor's stock relays including AN approved series, telephone, keying, midget, hermetically sealed, sensitive types, etc.—Relays Sales, Inc., Box 186, West Chicago, Ill.

Circle **506** on inquiry card.

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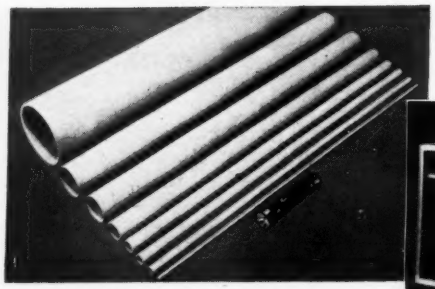

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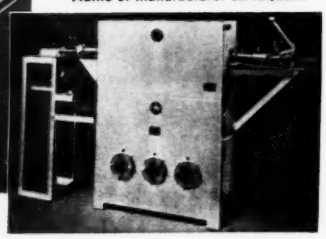

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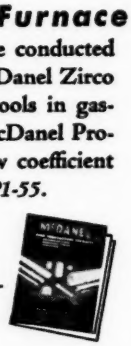

For more information circle **149** on inquiry card.

NEW LITERATURE

Contactors. New set of bulletins (159R1, 48R1, 509R1 and 1025 to 1045) cover maker's contactor combinations including multipole, and special arrangements and materials, a-c and d-c pole arrangements, etc.; magnetically held contactors in capacities from 30 to 300 amp for both ac and dc; and magnetically held feeder control switches, 200 to 1,000 amps.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **507** on inquiry card.

Relays. New 6-page illustrated Bulletin B32A3F presents specifications on maker's sensitive relays.—Milwaukee Gas Specialty Co., Milwaukee 1, Wisc.

Circle **508** on inquiry card.

Relay Specification. New 12-page article reprint covers factors affecting selection of electrical relays.—American Machinery & Foundry Co., 261 Madison Ave., New York 16, N.Y.

Circle **509** on inquiry card.

Solenoids. New 6-page Bulletin 200 presents maker's a-c and d-c solid frame solenoids and a-c laminated solenoids for continuous and intermittent duty.—Comar Electric Co., 3349 W. Addison St., Chicago 18, Ill.

Circle **510** on inquiry card.

Thermal Timing Relays. New 4-page Bulletin 130 presents specs for maker's thermal timing relays with time delays of two seconds to three minutes.—G-V Controls Inc., Hollywood Plaza, E. Orange, N. J.

Circle **511** on inquiry card.

Switches. New 12-page Catalog C presents maker's line of switches—toggle, slide, rotary, etc.—Carling Electric, Inc., 505 New Park Ave., W. Hartford 10, Conn.

Circle **512** on inquiry card.

Rotary Solenoids. New 6-page bulletin presents line of ac rotary solenoids.—Leetronics, Div., Lee Spring Co., Inc., 30 Main St., Brooklyn, N. Y.

Circle **513** on inquiry card.

Contactors. New 16-page Bulletin (includes Bulletins 1025-1045) presents data on maker's ac or dc magnetically held contactors. Includes two 2-page price lists.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **514** on inquiry card.

Switches. New 16-page booklet "Micro Tips Digest" presents 43 applications of snap-action switches.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **515** on inquiry card.

Selector Switch. New 4-page Bulletin presents maker's 8 and 10-position miniature selector switch for high-speed operation.—Electro Tec Corp., S. Hackensack, N. J.

Circle **516** on inquiry card.

Limit Switches. New 4-page Bulletin 356 describes maker's limit switches that provide nineteen contact arrangements in seven models.—R. B. Denison Mfg. Co., 102 St. Clair Ave., N.W., Cleveland 13, Ohio.

Circle **517** on inquiry card.

Rotary Switch. New 2-page Data Sheet 203 presents maker's 12-position, subminiature rotary switch with over-all o.d. of 1.160" including contacts.—International Instruments Inc., P. O. Box 2954, New Haven 15, Conn.

Circle **518** on inquiry card.

Switches. New 12-page Catalog C describes maker's line of push, slide, toggle and rotary switches.—Carling Electric, Inc., 505 New Park Ave., W. Hartford 10, Conn.

Circle **519** on inquiry card.

Relays. Two new 2-page Bulletins describe maker's general-purpose relays: a 5-amp subminiature type that withstands 50 G shock along three major axes, and a 2-amp micro-miniature relay.—Brubaker Electronics, Inc., 3652 Eastham Drive, Culver City, Calif.

Circle **520** on inquiry card.

Switches. New 4-page Data Sheet #3 presents maker's subminiature pushbutton and toggle switches.—Mi-li-Switch Corp., 1742 Berkeley St., Santa Monica, Calif.

Circle **521** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Current Transformers. New 2-page Bulletin GEC-1379 describes maker's 600 volt indoor instrument transformer for switchboard and switchgear applications.—General Electric Co., Schenectady 5, N.Y.

Circle **522** on inquiry card.

Electronic Instruments. New 256-page Catalog O presents maker's large line of electronic parts and apparatus—amplifiers, bridges, oscilloscopes, generators, variacs, etc. Make requests direct on company letterhead.—General Radio Co., 275 Mass. Ave., Cambridge 39, Mass.

Circle **523** on inquiry card.

Meter Relays. New 2-page flyer describes maker's Model 85 3" ac or dc meter relay for alarm, control and limit setting applications; also Model 185 2" dc type.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **524** on inquiry card.

CR Oscillographs, ITV Cameras. New 4-page bulletin presents maker's 21 new instruments, including maker's cathode-ray oscillographs, tubes, ITV cameras, and intercom equipment.—Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.

Circle **525** on inquiry card.

Volt-ohm-milliammeters. New 6-page Bulletin 2056 describes maker's line of test instruments including ac and dc volt-ohmmeters.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **526** on inquiry card.

Digital Voltmeters, Ohmmeters. Three new 4-page bulletins present maker's digital voltmeters and ohmmeters: Form 6752 describes and illustrates maker's a-c d-c digital volt-

meter; Form 6801 presents fully automatic d-c voltmeter with continuous automatic calibration; and Form 6581 presents digital ohmmeters with in-line digital readout.—Electro Instruments, Inc., 3794 Rosecrans St., San Diego 10, Calif.

Circle **527** on inquiry card.

Cable Tester. New 4-page bulletin presents maker's dc high-potential test and cable-fault locating set.—Peschel Electronics, Inc., 13 Garden St., New Rochelle, N. Y.

Circle **528** on inquiry card.

Noise Filter. New 2-page Bulletin S-317 describes maker's "magneFILTER" a seismic time domain filter system for linear or non-linear filtering of noise from broadband energy.—Houston Technical Labs., 2424 Branard, Houston 6, Texas.

Circle **529** on inquiry card.

Digital Voltmeter. New 4-page Bulletin 104-1 presents maker's "Teleducer" for push button automatic digital voltage measurement of up to 100 data channels with printed decimal readout.—Telecomputing Corp., Burbank, Calif.

Circle **530** on inquiry card.

Electronic Relay. New 2-page Data Sheet describes maker's electronic relay with four-way switch that enables fail-safe operation of alarm and temperature-control systems.—Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill.

Circle **531** on inquiry card.

VVLF Field Intensity. New 4-page Bulletin describes maker's new VVLF (30 cps to 15 kc) tunable, radio interference and field intensity measuring equipment.—Stoddart Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.

Circle **532** on inquiry card.

Microwave Equipment. New 16-page Bulletin PC-6527 presents maker's microwave communications equipment, installations, and specifications of new "CLR-7" relay.—Philco Corp., Government & Industrial Div., 4700 Wissachickon Ave., Phila. 44, Pa.

Circle **533** on inquiry card.

Volt-ammeters. New 4-page brochure presents maker's "Model A" portable d-c volt-ammeter with 40 ranges.—Sen Dur Mfg. Co., 3225 N. Sheffield Ave., Chicago, Ill.

Circle **534** on inquiry card.

Signal Converter. New 2-page bulletin presents data on maker's "Model 108" 3-channel instrument signal converter for measurement of aircraft and laboratory physical parameters.—Dynalysis Development Laboratories, Inc., 11941 Wilshire Blvd., Los Angeles 25, Calif.

Circle **535** on inquiry card.

Microwave Test Equipment. New 28-page Catalog describes maker's line of microwave test equipment, coaxial and uhf equipment, bolometers, thermistors, fixed and variable attenuators, tees, etc.—The Narda Corp., 160 Herricks Rd., Mineola, L.I., N.Y.

Circle **536** on inquiry card.

Telesync Signal Generator. New 2-page Bulletin presents maker's "Telesync" that supplies sync signals to operate a camera chain or slide equipment.—Nems Clarke, Inc., 919 Jesup-Blair Drive, Silver Spring, Md.

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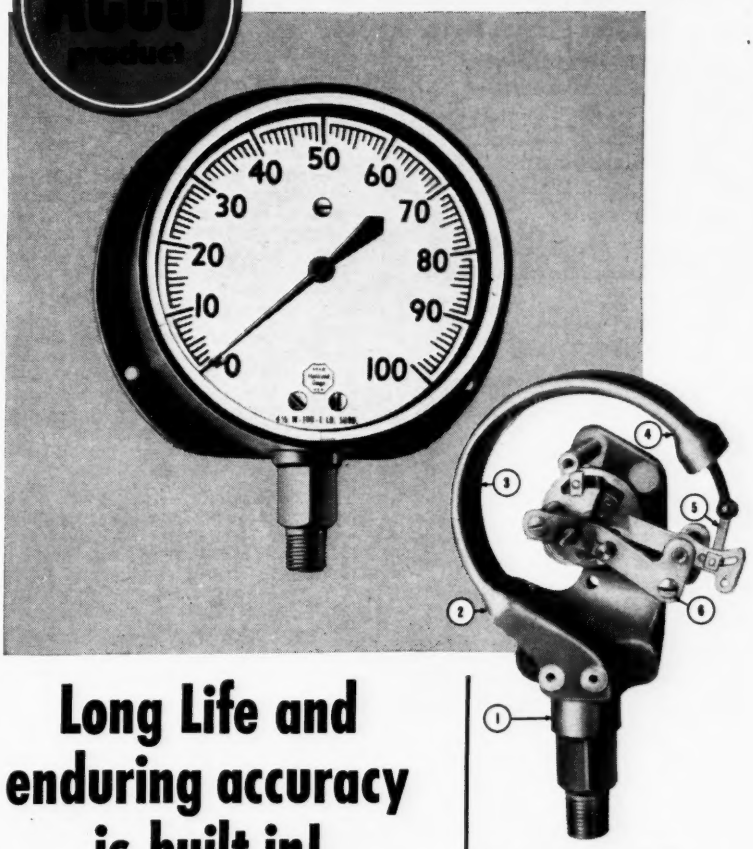

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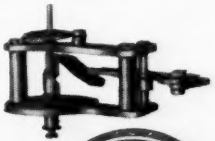

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NEW LITERATURE

VHF-UHF Signal Generator. New 6-page Bulletin presents maker's direct reading signal generator and accessories for testing and aligning vhf-uhf communication receivers.—New 2-page Bulletin describes maker's linear amplifier with self-contained power supply for ham operations.—Transitron, Inc., 186 Granite St., Manchester, N. H.

Circle **538** on inquiry card.

Spectrum and Waveform Analysis. New 4-page Catalog Digest presents maker's equipment for high-speed spectrum and waveform analysis, with visual display.—Panoramic Radio Products, Inc., 9 S. Second Ave., Mount Vernon, N. Y.

Circle **539** on inquiry card.

Electronic Instruments. New 4-page Short Form Catalog B presents maker's power supplies, power amplifier, variable electronic filters and wide range RC oscillators.—Krohn-Hite Instrument Co., 580 Massachusetts Ave., Cambridge 39, Mass.

Circle **540** on inquiry card.

Sweep Generator. New 2-page Leaflet presents maker's "Sweep-Sync" automatic sweep generator that provides stable oscilloscope displays automatically in the frequency range of 5 to 100,000 cps.—Chadwick-Helmuth Co., 472 E. Duarte Rd., Monrovia, Calif.

Circle **541** on inquiry card.

ELECTRONIC COMPONENTS

Condenser Microphones. New 16-page "Bruel & Kjaer Technical Review" (No. 3, July '55) is illustrated article on non-linearity of condenser microphones.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle **542** on inquiry card.

Radar Tubes. New 2-page Leaflet presents specs for maker's miniaturized high-resolution, cathode-ray tubes for airborne and portable radar receivers.—Industrial Tube Sales Dept., Allen B. Du Mont Labs., Inc., 2 Main Ave., Passaic, N. J.

Circle **543** on inquiry card.

Capacitors. New 18-page "Capacitor Digest" GED-2978 stresses cost savings available from engineered application of industrial capacitors.—General Electric Co., Schenectady 5, N. Y.

Circle **544** on inquiry card.

Connectors. New 2-page Bulletin 26A presents maker's miniature precision Continental Connectors including hoods and special designs.—DeJur-Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle **545** on inquiry card.

CR Tube. New 4-page Bulletin describes maker's "Type 7ACP19" three-beam cathode ray tube.—T. R. Lowenthal Co., 7526 Sheridan Rd., Chicago 26, Ill.

Circle **546** on inquiry card.

Transistors. New 8-page "Application Note" AN-165 describes use of maker's "2N109" p-n-p junction transistor in class B operation in output stage of low-power audio amplifiers. —Semiconductor Div., Radio Corp. of America, Harrison, N.J.

Circle **547** on inquiry card.

Tubes. New 8-page "Application Note" AN-164 describes method for determining approximate characteristics of an electron tube when all electrode voltages are changed in same proportion from published or measured values.—Tube Div., Radio Corp. of America, Harrison, N. J.

Circle **548** on inquiry card.

Transformers. New 32-page General Catalog TR-56 illustrates and lists maker's miniature, low-level, geophysical, etc. transformers. Also covers TV components and amplifier kits.—Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.

Circle **549** on inquiry card.

B-B Transformers. New 12-page Bulletin GED-2506A presents quick information on bucking or boosting voltage, connection diagrams, kva ratings, and other features for selection of maker's dry-type boost-or-buck transformers and autotransformers.—General Electric Co., Schenectady 5, N.Y.

Circle **550** on inquiry card.

Plug-in Circuits. New 4-page bulletin presents maker's "Encapsor" plug-in electronic circuits—amplifiers, gates, mixers, etc.—hermetically embedded in thermosetting plastic.—Alcor Electronics Corp., 180 Lafayette St., New York 13, N. Y.

Circle **551** on inquiry card.

Microwave Components. New 22-page loose leaf Catalog presents a wide range of standard and custom-engineered microwave components and complex mechanical assemblies.—J-V-M Engineering Co., Dept. IXP, 8846 W. 47 St., Brookfield, Ill.

Circle **552** on inquiry card.

Ballasts. New 12-page Bulletin GEC-983H (revised March '56) presents specifications wiring diagrams and prices of maker's ballasts for fluorescent lamps.—General Electric Co., Schenectady 5, N. Y.

Circle **553** on inquiry card.

Pulse Transformers. New 2-page Bulletin describes maker's blocking oscillator pulse transformers designed to produce a variety of pulse widths from 0.2 to 10 usec.—Brubaker Electronics, Inc., 3652 Eastham Drive, Culver City, Calif.

Circle **554** on inquiry card.

Tube Selection Chart. New 2-page chart ETD-1163-A lists maker's 600-milliampere series-string receiving type tubes, all of controlled heater warm-up design. 48 tube types are classified according to elements; average characteristics are given; and typical service, heater voltages, maximum plate and screen dissipation ratings are listed.—General Electric Co., Tube Dept., Schenectady 5, N. Y.

Circle **555** on inquiry card.

Fuses. New 20-page Catalog 56 describes maker's non-indicating and indicating fuses and aircraft limiters. —Sightmaster Corp., 111 Cedar St., New Rochelle, N. Y.

Circle **556** on inquiry card.

Photocell. New 6-page bulletin presents characteristics of CL-2 cadmium

Continued on page 1432

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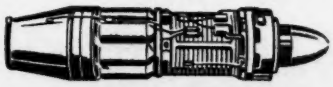

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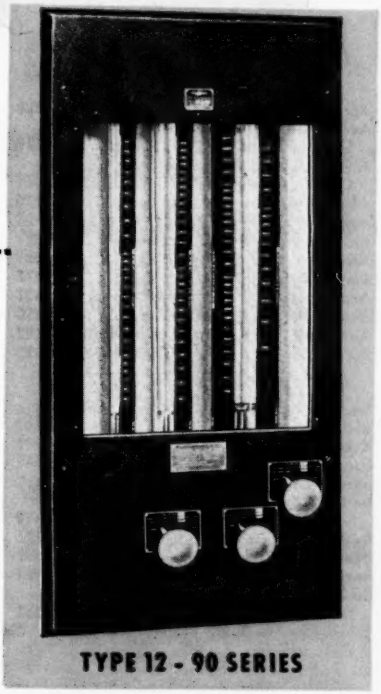

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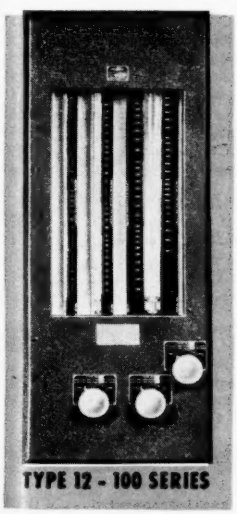

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For more information circle **152** on inquiry card.

INSTRUMENTS and AUTOMATION

Advertisers' Index

Acromark Company 1386
Aero Research Instrument Company, Inc. 1415
A'G'A Division of Elastic Stop Nut Corp. of America 1409
Aircraft-Marine Products, Inc. 1269, 1270
American Chain & Cable Co. 1427
American Machine & Metals, Inc. 1381
American Time Products, Inc. 1359
Amperite Co., Inc. 1377
Amthor Testing Instrument Co., Inc. 1422
Automatic Electric Mfg. Co. 1350
Automatic Electric Sales Corporation 1282
Automatic Temperature Control Co. 1390

Bacharach Industrial Instrument Co. 1416
Bailey Meter Company 1246-1247
Baker & Company, Inc. 1398
Baldwin-Lima-Hamilton Corporation 1251
Barber-Colman Company 1412
Barber-Colman Company, Wheelco Instruments Division 1419
Barksdale Valves 1276
Beede Electrical Instrument Co., Inc. 1412
Bendix Aviation Corporation 1272, 1403
Berkeley Division, Beckman Instruments, Inc. 1250
BJ Electronics, Borg-Warner Corporation 1285
Black, Sivalls & Bryson, Inc. 1420
Bourns Laboratories 1244
Bridgeport Thermostat Div. 1411
Bristol Company 1254-1255
Brown Instruments Division of Minneapolis-Honeywell Regulator Co. 1334-1335, 1371
Burnell & Co., Inc. 1249
Burroughs Corporation 1288

Chatillon & Sons, John 1261
Cohn Mfg. Co., Inc., Sigmund 1396
Comar Electric Company 1416
Commercial Research Laboratories, Inc. 1429
Computer Div., Bendix 1403
C.O.M.S.I.P. 1432
Conax Corporation 1410
Consolidated Electrodynamics Corporation 1242, 1375, 1405, 1413
Cosa Corporation 1378
Curtiss-Wright Corporation 1341, 1424

Dahl Co., Inc., George W. 1396
Dietert Co., Harry W. 1415
Dwyer Mfg. Co., F. W. 1413

Eastman Kodak Company 1413
EECO Production Company 1394
Electronic Associates Inc. 1336
Elgin National Watch Company 1414
Ellis & Sons, Inc., George D. 1432
Eppley Laboratory, Inc. 1279
Epsco, Incorporated 1423
Esso Standard Oil Company 1424

Fairchild Controls Corporation, Components Division 1398
Falstrom Company 1238
Fischer & Porter Co. ..... Inside Back Cover
Fisher Governor Company 1240
Foxboro Company 1258-1259, 1331
Fredericks Co., George E. 1284

Gaertner Scientific Corporation 1402
General Electric Company 1277
General Motors Corporation 1399
Giannini & Co., Inc., G. M. 1393
Green Instrument Company 1384
Gubelman Publishing Company 1382
G-V Controls Inc. 1417

Hagen Manufacturing Company, Inc. 1245
Hammel-Dahl Company ..... Back Cover
Hankison Corporation 1264
Haydon Company, A. W. 1397
Heiland, Div. of Minneapolis-Honeywell Regulator Co. 1286
Heise Bourdon Tube Company, Inc. 1351
Helicoid Gage Division 1427
H. J. J. Company 1370
Hoke Incorporated 1271
Hughes Aircraft Company 1265, 1379
Hughes Research and Development Laboratories 1264
Hunter Manufacturing Company 1422

Illinois Testing Laboratories, Inc. 1410
Imperial Brass Mfg. Co. 1380
Imtra Corporation 1380
Induction Motors Corp. 1241
Instrof Corp. 1425
Instruments Publishing Company 1260, 1332-33
International Business Machines Corporation 1296
International Optical Co., Inc. 1432

Jerguson Gage & Valve Company 1366
Johnson Engineering Company, Inc., Welton V. 1378
Jones Optical Works, A. D. 1417
Joy Manufacturing Company 1268

Kearfott Company, Inc. 1385
Kester Solder Company 1417
King Engineering Corp. 1428
Kruger Instruments, Harold 1421

Leeds & Northrup Co. 1292
Lepel High Frequency Laboratories, Inc. 1383
Lewis Engineering Co. 1252
Lynn, Robert M. 1289

Mack Electric Devices, Inc. 1432
Magnetic Research Corp. 1248
Mallory & Co., Inc., P. R. 1357
Manning, Maxwell & Moore, Inc. 1281, 1349
Marsh Instrument Co. 1414
Marshalltown Mfg. Co. 1408
McDanel Refractory Porcelain Company 1426
McDonnell Aircraft Corporation 1382
Meriam Instrument Company 1289
Mico Instrument Co. 1421
Mid-Century Instrumatic Corp. 1342
Midwestern Instruments ..... Inside Front Cover
Minneapolis-Honeywell Regulator Co., Industrial Division 1291, 1334-1335, 1371
Moeller Instrument Company 1280
Moog Valve Co., Inc. 1275
Moseley Co., F. L. 1392
Moser Jewel Company 1411

Nash Engineering Company 1373
Niagara Blower Company 1369
North American Instruments, Inc. 1372
North American Van Lines, Inc. 1431

Ohmite Manufacturing Company 1401

Palmer Thermometers, Inc. 1382
Perkin Engineering Corp. 1237
Philadelphia Thermometer Co. 1410
Pioneer-Central Division, Bendix 1272
Pritchard & Co. of California, J. F. 1354, 1395
Progressive Service Co. 1408
Pyrometer Instrument Co. 1372

Q-O-S Corporation 1387

Radiation Inc. 1283
Rawson Electrical Instrument Company 1396
Remington Rand Univac 1278
Republic Manufacturing Co. 1412
Rex Rheostat Co. 1412
Richard Rimbach Associates 1284, 1343, 1388
Robbins Aviation 1370
Rochester Manufacturing Co., Inc. 1385
Rubicon Company 1274
Ruge Associates, Inc., Arthur C. 1404

Schaevitz Engineering 1409
Scherr Optical Tools, Inc., Geo. 1415
Sensitive Research Instrument Corporation 1238
Shore Instrument & Mfg. Co., Inc. 1374
Skinner Electric Valve Division 1256
Smith Company, S. Morgan 1389
Sorensen & Company 1263
Southwestern Industrial Electronics Co. 1391
Sparks-Withington Co. 1432
Stackpole Carbon Co. 1411
Standard Electric Time Company 1267
Statham Laboratories 1243
Superior Tube Company 1290
Swartwout Company 1363

Technical Charts, Incorporated 1425
Technique Associates, Inc. 1384
Thermco Laboratories 1408
Thermo Electric Co., Inc. 1395

Uehling Instrument Co. 1376
Unertl Optical Co., John 1374
United States Gauge, Div. of American Machine & Metals, Inc. 1381
United States Radium Corporation 1399

Veeder-Root Incorporated 1361

Wallace & Tiernan Incorporated 1273
Waugh Engineering Company 1397
Weckesser Co. 1376
Welch Scientific Company, W. M. 1353
Weston Electrical Instrument Corporation 1407
Westronics, Inc. 1416
Wheelco Instruments Div., Barber-Colman Company 1419
Wilmad Glass Company, Inc. 1414
Winzeler Manufacturing & Tool Co. 1409

Zeiss, Inc., Carl 1423

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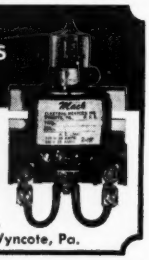

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NEW LITERATURE

sulphide photoconductive cells. 2-page bulletin presents tentative characteristics on CL-3, a cadmium selenide photoconductive cell.—Clairex Corp., 50 W. 26 St., New York 10, N. Y.

Circle **557** on inquiry card.

Photoconductive Cell. New 4-page Bulletin 6694-A presents maker's cadmium-sufide type photoconductive cell with high sensitivity, low dark current, low noise and proportional output.—Tube Div., Radio Corp. of America, Harrison, N. J.

Circle **558** on inquiry card.

Waveguides. New 12-page Catalog C-356 describes makers line of E and H plane bends and hybrid junctions.—Microwave Development Labs., Inc., 92 Broad St., Babson Park, Wellesley 57, Mass.

Circle **559** on inquiry card.

RESISTORS, POTENTIOMETERS

Resistors, Capacitors. New 8" x 11" Plastic Chart lists color code of maker's ½-, 1-, and 2-watt, fixed-composition resistors in 269 RETMA values, and fixed-composition capacitors for low-capacity requirements in 46 RETMA values.—Stackpole Carbon Co., St. Marys, Pa.

Circle **560** on inquiry card.

Potentiometers, Pressure Switches. New 4-page bulletin presents maker's line of potentiometers, stepping positioner, pressure switches, and pressure transmitter for industrial and aircraft control, and computer systems.—Electromechanical Div., G. M. Giannini & Co., Inc., Caldwell Township, N. J.

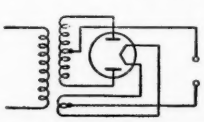
Circle **561** on inquiry card.

Wirewound Resistors. New 4-page Bulletin B-5 tabulates specs on insulated wirewound resistors including balanced or matched pairs for close tolerance requirements.—International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Circle **562** on inquiry card.

Resistance Wire. New 2-page Bulletin tabulates data on maker's new 0.0005" dia. enameled "Karma" wire rated at 3200 ohms per ft.—Driver-Harris Co., Harrison, N. J.

Circle **563** on inquiry card.



POWER SUPPLIES

Power Supply. New 2-page Bulletin M562 describes maker's 400-cps, 115-v, single phase power supply with dc output of 5 V at 1 amp. for strain gages and telemetering equipment in aircraft systems.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

Circle **564** on inquiry card.

Power Supplies. New 4-page Bulletin B356 presents maker's dc and voltage regulated power supplies.—Kepco

NEW LITERATURE

Laboratories, 131-38 Sanford Ave., Flushing 55, N. Y.

Circle **565** on inquiry card.

Power Supplies. New 2-page Bulletin 2-15-56 describes ac-operated dc power packs, miniaturized and potted in transformer type housings.—New 2-page Catalog 1-30-56 describes transistorized, regulated, dc power supplies for low and medium voltage applications.—Electronic Research Associates, Inc., 67 E. Centre St., Nutley, N. J.

Circle **566** on inquiry card.

TUBING, FITTINGS

Tubing. New 12-page Catalog describes maker's stainless steel, nickel and nickel alloy tubing from 0.008" to 1.000" o. d. with 0.003" to 0.083" wall, and includes tubular fabricated parts.—J. Bishop & Co. Platinum Works, Stainless Steel Prod. Div., Malvern, Pa.

Circle **567** on inquiry card.

Pneumatic Disconnect. New 2-page bulletin presents specs on maker's straight-through, single-check, self-sealing pneumatic disconnect.—Eastern Aircraft Products Corp., 229 River St., Orange, N. J.

Circle **568** on inquiry card.

Nickel Tubing. New 20-page Catalog 12 describes maker's nickel and nickel alloy tubing and tabulates mechanical properties and chemical compositions of 13 analyses.—Superior Tube Co., Norristown, Pa.

Circle **569** on inquiry card.

Plastic Tubing. New 8-page Bulletin 3E6-15 describes and illustrates applications of maker's "Nylaflow" flexible pressure tubing.—The Polymer Corp. of Penna., Reading, Pa.

Circle **570** on inquiry card.

Nylon Fittings. New 2-page Bulletin tabulates maker's new 2-piece nylon tubing fittings.—Thomas Associates, 4607 Alger St., Los Angeles 39, Calif.

Circle **571** on inquiry card.

MECHANICAL COMPONENTS

Power Drive Couplings. New 4-page Bulletin MC-100 presents maker's standard and special miniature couplings for power transmission.—Thomas Flexible Coupling Co., Warren, Pa.

Circle **572** on inquiry card.

Variable-Speed Transmissions. New 12-page catalog presents features and applications of maker's variable-speed transmissions.—Maureymatic Div., Maurey Mfg. Corp., 2915 S. Wabash Ave., Chicago 16, Ill.

Circle **573** on inquiry card.

Nameplates. New 4-page Bulletin illustrates and describes maker's all-purpose aluminum nameplates for use on irregular surfaces and crinkle finishes.—North Shore Nameplate Inc., 214 Northern Blvd., Bayside, L.I., N.Y.

Circle **574** on inquiry card.

Rivets. New 16-page Price List 42 presents maker's line of semi-tubular, full tubular and split rivets, bag studs

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2	27	52	77	102	127	152	202	227	252	277	302	327	352	402	427	452	477	502	527	552	577
3	28	53	78	103	128	153	203	228	253	278	303	328	353	403	428	453	478	503	528	553	578
4	29	54	79	104	129	154	204	229	254	279	304	329	354	404	429	454	479	504	529	554	579
5	30	55	80	105	130	155	205	230	255	280	305	330	355	405	430	455	480	505	530	555	580
6	31	56	81	106	131	156	206	231	256	281	306	331	356	406	431	456	481	506	531	556	581
7	32	57	82	107	132	157	207	232	257	282	307	332	357	407	432	457	482	507	532	557	582
8	33	58	83	108	133	158	208	233	258	283	308	333	358	408	433	458	483	508	533	558	583
9	34	59	84	109	134	159	209	234	259	284	309	334	359	409	434	459	484	509	534	559	584
10	35	60	85	110	135	160	210	235	260	285	310	335	360	410	435	460	485	510	535	560	585
11	36	61	86	111	136	161	211	236	261	286	311	336	361	411	436	461	486	511	536	561	586
12	37	62	87	112	137	162	212	237	262	287	312	337	362	412	437	462	487	512	537	562	587
13	38	63	88	113	138		213	238	263	288	313	338	363	413	438	463	488	513	538	563	588
14	39	64	89	114	139		214	239	264	289	314	339	364	414	439	464	489	514	539	564	589
15	40	65	90	115	140		215	240	265	290	315	340	365	415	440	465	490	515	540	565	590
16	41	66	91	116	141		216	241	266	291	316	341	366	416	441	466	491	516	541	566	591
17	42	67	92	117	142		217	242	267	292	317	342	367	417	442	467	492	517	542	567	592
18	43	68	93	118	143		218	243	268	293	318	343	368	418	443	468	493	518	543	568	593
19	44	69	94	119	144		219	244	269	294	319	344	369	419	444	469	494	519	544	569	
20	45	70	95	120	145		220	245	270	295	320	345		420	445	470	495	520	545	570	
21	46	71	96	121	146		221	246	271	296	321	346		421	446	471	496	521	546	571	
22	47	72	97	122	147		222	247	272	297	322	347		422	447	472	497	522	547	572	
23	48	73	98	123	148		223	248	273	298	323	348		423	448	473	498	523	548	573	
24	49	74	99	124	149		224	249	274	299	324	349		424	449	474	499	524	549	574	
25	50	75	100	125	150		225	250	275	300	325	350		425	450	475	500	525	550	575	

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1	26	51	76	101	126	151	201	226	251	276	301	326	351	401	426	451	476	501	526	551	576
2	27	52	77	102	127	152	202	227	252	277	302	327	352	402	427	452	477	502	527	552	577
3	28	53	78	103	128	153	203	228	253	278	303	328	353	403	428	453	478	503	528	553	578
4	29	54	79	104	129	154	204	229	254	279	304	329	354	404	429	454	479	504	529	554	579
5	30	55	80	105	130	155	205	230	255	280	305	330	355	405	430	455	480	505	530	555	580
6	31	56	81	106	131	156	206	231	256	281	306	331	356	406	431	456	481	506	531	556	581
7	32	57	82	107	132	157	207	232	257	282	307	332	357	407	432	457	482	507	532	557	582
8	33	58	83	108	133	158	208	233	258	283	308	333	358	408	433	458	483	508	533	558	583
9	34	59	84	109	134	159	209	234	259	284	309	334	359	409	434	459	484	509	534	559	584
10	35	60	85	110	135	160	210	235	260	285	310	335	360	410	435	460	485	510	535	560	585
11	36	61	86	111	136	161	211	236	261	286	311	336	361	411	436	461	486	511	536	561	586
12	37	62	87	112	137	162	212	237	262	287	312	337	362	412	437	462	487	512	537	562	587
13	38	63	88	113	138		213	238	263	288	313	338	363	413	438	463	488	513	538	563	588
14	39	64	89	114	139		214	239	264	289	314	339	364	414	439	464	489	514	539	564	589
15	40	65	90	115	140		215	240	265	290	315	340	365	415	440	465	490	515	540	565	590
16	41	66	91	116	141		216	241	266	291	316	341	366	416	441	466	491	516	541	566	591
17	42	67	92	117	142		217	242	267	292	317	342	367	417	442	467	492	517	542	567	592
18	43	68	93	118	143		218	243	268	293	318	343	368	418	443	468	493	518	543	568	593
19	44	69	94	119	144		219	244	269	294	319	344	369	419	444	469	494	519	544	569	
20	45	70	95	120	145		220	245	270	295	320	345		420	445	470	495	520	545	570	
21	46	71	96	121	146		221	246	271	296	321	346		421	446	471	496	521	546	571	
22	47	72	97	122	147		222	247	272	297	322	347		422	447	472	497	522	547	572	
23	48	73	98	123	148		223	248	273	298	323	348		423	448	473	498	523	548	573	
24	49	74	99	124	149		224	249	274	299	324	349		424	449	474	499	524	549	574	
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NEW LITERATURE

and rivet caps; also single and multiple automatic rivet setters.—Chicago Rivet & Machine Co., 950 S. 25 Ave., Bellwood, Ill.
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Machine Tool Clutches. New 4-page Bulletin ECP-656 describes applications of maker's "Electro Clutch" with min. shaft dia. of 0.0669" used where many output speeds are desired with a constant input speed.—I-T-E Circuit Breaker Co., Phila. 30, Pa.
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MATERIALS

Beryllium Copper. New 4-page Bulletins describe terminal and connector applications for beryllium copper alloy. Bulletin 34 describes sleeve spring application; second bulletin presents maker's "Berylco" 10 strip.—The Beryllium Corp., Reading, Pa.
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Mica. New 3-page article describes how (electronically) "K" gauged mica permits manufacture of small capacitors.—Perfection Mica Co., 1829 Civic Opera Bldg., 20 N. Wacker Drive, Chicago 6, Ill.
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Teflon Rod. New 2-page Price List T-556 presents a variety of lengths and diameters of maker's extruded Teflon rod.—Tri-Point Mfg., Inc., 401 Grand St., Brooklyn 11, N. Y.
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Teflon. New 14-page Catalog T-55 describes properties and specs on maker's sheets, rods, tubes, tapes and gaskets made from "Teflon."—Continental-Diamond Fibre, Newark, Del.
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Brass Castings. New 4-page bulletin outlines economical uses of brass pressure die castings.—Titan Metal Mfg. Co., Bellefonte, Pa.
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Bonding Agents. New 46-page brochure describes maker's epoxy resin bonding agents, adhesives, potting compounds and metal putty.—Carl H. Biggs Co., 2255 Barry Ave., W. Los Angeles 64, Calif.
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Cementable Teflon Tape. New 2-page Bulletin AD158 describes cementable "Teflon" tape in thicknesses as low as 0.005".—Garlock Packing Co., Plastics Div., P.O. Box 93, Camden 1, N. J.
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FABRICATION

Welding. New 8-page Bulletin GEA-6028A describes and illustrates maker's "Fullerarc" consumable electrode gas-shielded welding equipment for non-ferrous metals such as aluminum, copper, nickel, etc.—General Electric Co., Schenectady 5, N. Y.
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Aluminizer. New 4-page Bulletin 405 describes and illustrates maker's "Model CRS-48" aluminizer for high-vacuum coating of TV tubes.—Kinney Mfg. Div., The New York Air Brake Co., 3539 Washington St., Boston 30, Mass.
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Engravers, Fly Cutters. New 4-page Catalog features uhf coaxial wavemeters and includes miniature transformers, fly cutters and grinder, and nameplate engraving equipment.—Mico Instrument Co., 80 Trowbridge St., Cambridge, Mass.
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Wire Splicing. New 4-page Bulletin 90-B1 and describes maker's new "Scotchcast" splicing kit affording moisture-proof splice protection for Y-splices in field.—Minnesota Mining and Mfg. Co., 900 Fauquier St., St. Paul 6, Minn.
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Work Benches. New 4-page Bulletin SC 100 describes maker's portable, self-contained, dust-free, work bench.—The Baker Co., Inc., Maplewood, Maine.
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TOOLS

Twist Drills. New 12-page Catalog A presents maker's line of carbon and high-speed twist drills and blanks.—Precision Twist Drill & Machine Co., 10 Woodstock St., Crystal Lake, Ill.
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Abrasive Wheels. New 4-page bulletin No. 56-4 describes maker's line of surface grinding wheels, and explains meaning of wheel code numbers.—The DoALL Co., Des Plaines, Ill.
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Dial Saw. New 4-page bulletin describes dial saw with increased cutting range for holes up to 3½" dia.—Robertson and Ruth, Dial Saw Div., Box 534, Elmhurst, Ill.
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Micro Collet Chuck. New 1-page bulletin describes maker's adjustable collet chuck for small tools.—Detroit Cam & Tool Co., 2305 Goodrich Ave., Ferndale 20, Mich.
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Hand Files. New 8-page Bulletin 356 presents maker's line of hand files and production applications.—Grobet File Co. of America, Inc., Carlstadt, N. J.
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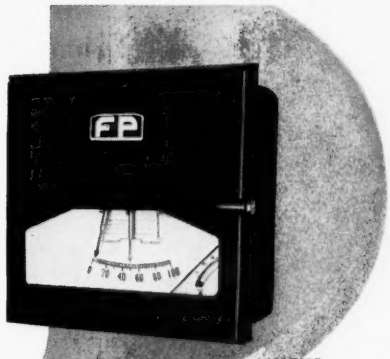

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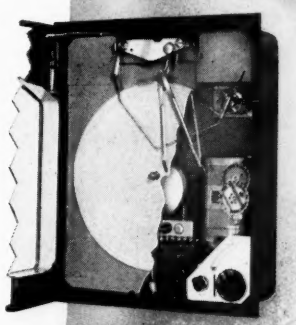

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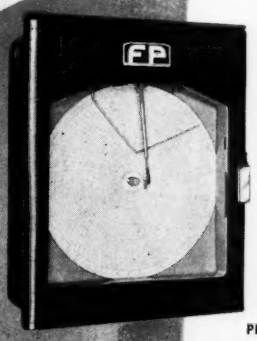

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